CASSELL'S NATURAL HISTORY

F. MARTIN DUNCAN

CHRIST'S HOSPITAL
15 OCT 1932
SCIENCE SCHOOL

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CASSELL'S NATURAL HISTORY · By F. Martin Duncan, F.R.P.S., F.R.M.S., Member of the Marine Biological Association of the United Kingdom, Author of "Denizens of the Deep," etc.

WITH 8 COLOUR PLATES AND 140 ILLUSTRATIONS FROM PHOTOGRAPHS BY THE AUTHOR

CASSELL AND COMPANY, LIMITED
London, Toronto, Melbourne and Sydney

First published *October* 1913.
Reprinted *May* 1922.
„ *April* 1929.

Printed in Great Britain

INTRODUCTION

In the pages of this volume I have endeavoured to place before my readers in as simple and non-technical language as the theme permits (though the entire avoidance of technical terms has been neither possible nor desirable), the wonderful story of the gradual evolution of animal life, from the simplest unicellular organism to the most complex type. I have aimed to give a broad survey of the animal kingdom, describing only those creatures most typical or possessing some characteristic trait, from each division, rather than giving what in the space at my command would be the briefest possible description of a large number of animals. In this way each great division of the animal kingdom is placed, as it were, in a series of tableaux before the reader, the whole forming a pageant of animal life.

The study of animal life is full of interest and fascination, opening up new fields for investigation the farther one advances, always becoming more and more deeply absorbing as one's knowledge and experience increase. There is so much one would desire to know, and so short a time in which to accomplish it. And to-day, how infinitely wider and more interesting is our outlook upon the study of animal life! A hundred years ago, he who could correctly name and classify the largest number of specimens under their respective divisions was considered the greatest authority, though probably he had never seen any of them alive in their natural habitat. Classification—specie-mongering one might almost call it, with a total disregard for the importance of studying the living animal and its environment—was the almost universal order of the day. Indeed, the few men who had heard

the voice of Nature, and had gone forth into the fields and lanes, and along the seashore to pursue their studies, were laughed to scorn, or looked upon as revolutionary, if not dangerous heretics. But these early pioneers laboured not in vain; interest was aroused, and gradually the old pedantic, narrow outlook widened, until the publication of Darwin's "Origin of Species" established and vindicated for all time the importance of biology, the study of the organism in relation to environment.

Since that time the history of the study of animal life has been one of rapid and steady progress, fraught with far-reaching and important results. Take, for example, the rapid progress within the last fifteen or twenty years of our knowledge of the protozoa, and of the important part which we now know many of these unicellular organisms to play as the primary cause of many deadly tropical diseases, such as malaria, yellow fever, and sleeping sickness. Biological investigation has revealed not only the organisms that produce the malignant diseases, but the transmitting agents that carry them from man to man—discoveries of far-reaching economic importance, making for the commercial advance and prosperity of tropical lands, where formerly fevers rendered life almost insupportable. The engineer will proudly acclaim the completion of the Panama Canal as one of the wonders of mechanical science, but its successful accomplishment has only been rendered possible by biological research, through which the knowledge of how to combat the ravages of malaria and yellow fever among the vast army of workers employed upon the undertaking has been acquired.

The study of life in the sea—marine biology—has made considerable progress of late years, and is becoming of ever greater importance, not only from the purely scientific point of view, but in connection with fishery questions and the "harvest of the sea." Thanks to the energy of Sir E. Ray Lankester, the Marine Biological Association of the United Kingdom was founded in 1884, and since its inception has carried out investigations of far-reaching scientific and economic importance, adding to our

knowledge of the life, habits, and migrations of various marketable marine fishes, their rate of growth, and the organisms upon which they feed: subjects to which I shall have occasion to refer in the chapter on marine fishes.

The occupation of wide areas of hitherto virgin country by civilised man is producing the most profound changes in the distribution of animal life, owing to the incessant and often senseless war of extermination which he wages upon the so-called "lower animals" in his conquest of the wild. Of the vast herds of bison which roamed the prairies of North America seventy years ago, but a few hundred head, if so many, survive to-day, carefully sheltered in reservations and zoological gardens. The fur seal has also been nearly exterminated, and the whales are doomed. Unless active steps are taken to protect them, the same fate awaits the whole of the large and many of the small quadrupeds, with the exception of those already under or amenable to domestication, and another hundred years will probably see their total extinction. So, too, with many of the birds; every year sees the disappearance of some gaily coloured species that helped alive to make the face of the earth more beautiful, slaughtered as an offering to woman's vanity, to satiate the barbaric lust of Fashion; while the so-called "sportsman" who shoots every rare bird at sight and the misguided agriculturist who cannot distinguish between those birds which, as insect eaters, are his best friends, and those which take serious toll of his seed, help on the work of destruction. That man will have to pay bitterly in the future for this ruthless destruction there can be no doubt, for the balance of Nature cannot be upset with impunity. The destruction of carnivorous animals automatically removes the natural check on the increase of those plant-devouring animals which formed their prey; while the disappearance of many species of birds can only foster the steady increase of crop-devouring hordes of insects.

It is impossible nowadays for one man to write or speak authoritatively out of his own personal knowledge upon the whole

of the animal kingdom, and therefore in writing the present book I have consulted the latest published works of the leading authorities on each division, so that I might have the benefit of their knowledge upon those divisions with which I am less familiar, as well as their confirmation upon those to which I have devoted many years of original research. I believe that in every case where extracts from other works have been included they have been placed between quotation marks and their authorship acknowledged either in the text or in a footnote. Whenever it has seemed desirable, the origin and full meaning of less familiar technical words have been given. The whole of the illustrations, both in colour and half-tone, have been prepared from my own original photographs. I would express my thanks to Mr. H. E. Garraway, of the Queensland Government Office, London, for enabling me to photograph a specimen of that deeply interesting animal the Ornithorhynchus, and also to my dear Wife for much valuable assistance.

If the book and its illustrations should help to awaken and stimulate an interest in the wonders and beauties of animal life, then my labours have not been in vain.

F. Martin Duncan.

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CHAPTER I

THE PROTOZOA—THE DAWN OF LIFE

The simplest members of the animal kingdom are called the **Protozoa,**[1] and, with few exceptions, are too minute to be clearly visible without the aid of a microscope, those which may be detected by the unaided eye appearing as tiny, inert specks or moving particles. They are universal in their geographical distribution, from the Equator to the Arctic and Antarctic, and are to be found living under the most varied conditions, in the soil, in stagnant pools, in rivers and lakes, and in the sea; while many live in the bodies of the higher animals and are responsible for some of the most serious and fatal diseases from which man and beast can suffer. Malaria, sleeping sickness and blackwater fever are inflicted by them on mankind, and rinderpest, nagana and surra on cattle and horses, the organisms being conveyed from one host to another through the agency of various biting insects. Primitive as these organisms are, they are not sufficiently so to be considered as primordial in the sense of being the first created animals; they must have been preceded by a still simpler organism, of which we have no definite knowledge, but to which the Amœba, and some of the Mycetozoa,[2] at certain stages, probably most nearly approach.[t] The riddle of the origin of life still remains unsolved, though its ultimate solution is within the bounds of possibility. If it is ever accomplished, there is little doubt that the key will be dredged up from out the sea.

In the light of the most recent scientific investigation, it is

[1] Greek, *prōtos*, first; *zoa*, animal. [2] Greek, *myces*, a fungus; *zoa*, animal.

now very generally considered that the dawn of life took place upon the wet sands, or in the quiet waters of some shallow sea of the primeval world; for the warm water-logged mud of the seashore would have been a specially suitable medium, owing to its constant temperature, its moisture, and soft surface, for the development and support of the first forms of animal life, and for the accumulation of the first formed organic matter from which these primordial organisms probably sprang; for the essential chemical constituents of living matter are all soluble in, and constituents of, sea-water.

The Protozoa are all organisms characterised by the comparative simplicity of their structure, and by existing either as single cells or colonies of similar cells, mere repetitions of each other, each capable of maintaining an independent existence. It is to these primitive organisms that we must first turn our attention if we are fully to realise the significance of all the beautiful and wonderful creatures, with their varied shapes and habits, to be met with in the animal kingdom, and how, step by step, the higher forms of animal life have been gradually evolved from simple forms.

Of the great antiquity of the Protozoa we have a graphic record in the rocks of the earth, for their fossil remains have been found in the oldest known rocks that have retained any indication of the existence of life on the earth. The limestones and sandstones of many mountain ranges are largely composed of the fossil remains of Protozoa; the wonderful pyramids of Egypt are really vast piles of an extinct Protozoon whose skeleton was about the size of a large pea; while the white chalk cliffs of old England are largely composed of the skeletons of these organisms; for while some Protozoa remain soft, jelly-like specks of changing form, leaving no record of their existence, others evolve the most exquisite skeletons of lime and silica, imperishable, outlasting the mountains they served to form.

We will begin our study of these primitive forms of animal life by examining a tiny microscopic creature to be found in the mud at the bottom of ponds and streams, and in the shallow pools on the seashore. It is called the Amœba, from an old Greek word which means changeful, and when first discovered was called the "Proteus Animalcule," after the changeable sea god of the ancient

Greeks. Under the microscope the Amœba looks like a tiny, semi-transparent jelly-speck, about $\frac{1}{100}$ inch in diameter, composed of a soft, slimy, semi-fluid substance in which can be seen a slightly denser globular body called the *nucleus*, the whole organism being very irregular and varying in shape, changing ever as we watch it, becoming round, oval, oblong, or lobed like a distorted hand—changes effected by the streaming of its protoplasm and the pushing out and withdrawal of blunt finger-like processes. As we watch the expansion and contraction of these finger-like processes, we shall see that as a result of their movements the whole mass of the Amœba is slowly drawn along, with a curious streaming sort of motion.

The Amœba may contract its finger-like expansions and come to a pause in its progress, and assuming a globular shape, secrete a thick, almost shell-like coat, probably composed of some nitrogenous substance, which completely envelops it, forming a cyst or cell-wall. The formation of this enveloping cyst is of very great importance to the Amœba. Protected by its horny case, it is enabled to survive periods of drought should the pond dry up during the summer months. When the rains of autumn replenish the pond, and conditions suitable for its active life are once more restored, the Amœba ruptures the cell-wall and makes its escape.

The Amœba moves continually in all directions, its constantly changing finger-like processes being merely temporary projections of its semi-fluid body, and not special organs in the anatomical sense for producing movements; hence the reason for their being called "*pseudopodia*," or "false-feet."

The jelly-like, somewhat granular substance called *protoplasm*,[1] of which the Amœba is composed, appears surrounded by an outer glassy-looking and extremely thin pellicle or layer.[2] In the interior mass of protoplasm may be made out the denser and small rounded body of the nucleus, which does not alter in form during the changes of shape which the Amœba undergoes as a whole. This nucleus consists of material closely resembling the

[1] From the Greek, *prōtos*, first; *plasma*, a formation, from *plasso*, I shape or mould. The simplest life-matter known, and present in the tissues of both plants and animals.

[2] The glassy outer portion is called by some observers the *ectoplasm*; the denser mass being called, in contradistinction, the *endoplasm*.

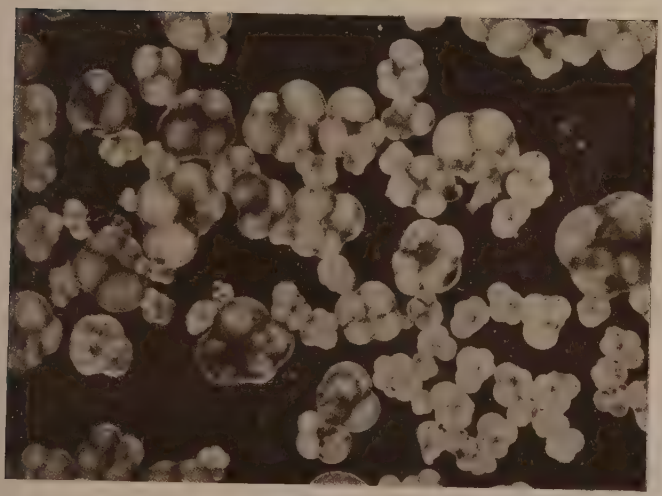
protoplasmic body mass, but is of a slightly higher refractivity, which renders it conspicuous; it contains granules of a substance called *chromatin*, because of the readiness with which it absorbs certain dyes.

Another minute feature which we shall see in the interior of the Amœba is a clear, rounded space in the protoplasm, which, as we watch it, will be seen gradually to increase in size up to a certain point when, by a sudden contraction of its walls, it will disappear from view, only to reappear in a short time and again expand. This transparent, pulsating space is called the *contractile vacuole*, and probably secures to some degree the aeration and purification of the mass of protoplasm.

If an Amœba be kept under observation for a little while, the streaming movements of the protoplasm will be seen not only to effect locomotion, but also to bring about the successful capture of food. The drop of water in which the Amœba is moving contains minute particles of mud, and also probably several of those unicellular plants called "Diatoms," which swarm in both fresh and sea water. Should one of these microscopic plants lie in the path of the Amœba, the latter will press one of its pseudopodia, or one side of its body, against the Diatom, which will be seen gradually to sink into the soft protoplasm and pass into the interior of the Amœba. The engulfed Diatom becomes surrounded by a little globule of watery fluid, and by degrees the whole of its soluble parts disappear, only the siliceous frustule or skeleton remaining. This insoluble skeleton is soon passed outwards from the protoplasm into the surrounding water; and the Amœba frequently appears to get rid of the frustule of the Diatom by the simple process of streaming away from it.

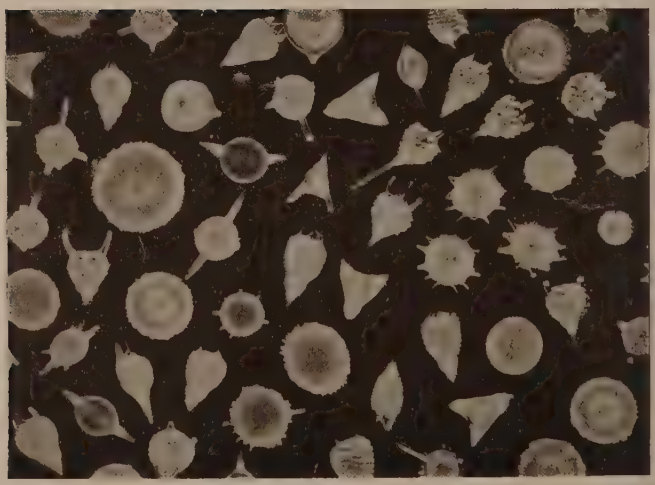
If food is abundant the Amœba increases in size, and it is not long before a very remarkable change takes place. The pseudopodia are withdrawn, partially if not entirely; the body mass begins to elongate; and a fissure appears, dividing the Amœba into two parts. As the waist-like constriction forms, the nucleus may be seen to divide into two, each half moving off into the two lobes of the dividing Amœba, so that when separation is completed, and we have two distinct Amœba resulting from the division of the one, each possesses a nucleus developed from the original nucleus. It is by this simple process of division into

Amœba with ingested diatoms



Globigerina Ooze

Foraminifera (*N. depressula*)



Radiolaria

two, *binary fission* as it is called, that reproduction or multiplication chiefly takes place in the Amœba and many of the Protozoa. It is hardly exact to call the two resulting Amœbæ the children of the original, for they are simply the original Amœba cut in halves; it is convenient, however, to speak of these products of binary fission as "daughter-cells."

The new Amœbæ absorb and assimilate food, thus adding new material to the original matter of the parent body, and then each of them again divides into two. So the process of food assimilation, growth, and subsequent division is repeated again and again, an ever lessening part of the actual body substance of the original ancestor being passed on to each succeeding generation. It is obvious, therefore, that an Amœba never dies a natural death, or, to put it another way, "no Amœba ever lost an ancestor by death." An Amœba may be killed outright, but in that case it leaves no descendants; but if it once produces new Amœbæ, it never dies, although it ceases to exist as a single individual.

Occasionally, two Amœbæ may be seen to flow towards each other, and fuse in a way which may be considered as an incipient form of sexual union, and this fusion acts undoubtedly as a revivifying process or "rejuvenescence," arresting that constitutional weakening which seems to be set up by, and the inevitable result of repeated fission.

As Professor F. W. Gamble states, "simple division carried beyond a certain number of cleavages appears to be ineffective. The process, though long, is not endless, and after a time it slows down and ceases. Exactly why it should do this is not very clear, but it would seem that the slackening is not due to deterioration of the environment so much as to some constitutional weakening. Any weakness is, owing to the simple cleavage of one into many, conveyed to the descendants, and there seems to be no rectifying property. It has been found that if such a strain or culture, the members of which are derived from a single Protozoon by repeated fission, is isolated, it gradually dwindles and dies. If, however, it is allowed access to another culture of exactly similar appearance, it undergoes renewal of this dividing property, and after an interval once more populates the water."

From the above brief description of the Amœba, it will be seen that although this interesting and remarkable organism is

but a single protoplasmic cell, yet it is capable of all the functions of a multicellular animal—movement, feeding, growth, reproduction—and that in it we have, to quote Professor Haeckel, "an approximate illustration of the ancient common unicellular ancestor of all the Metazoa, or multicellular animals."

Further, a simple Amœba has a striking resemblance to the "primary cell" or "ovum" of all animals, whether vertebrate or invertebrate. It may be regarded as equivalent to this unicellular stage which is the beginning of all the higher organisms. The so-called "white corpuscles" or leucocytes of our blood are amœboid. As they circulate along the blood-vessels, they execute movements like those of Amœbæ, constantly modifying their shape, and engulfing foreign substances, or organisms such as bacteria, which have entered the system, just in the same manner as the Amœba takes in its food.

While the distinction between the higher plants and animals is perfectly sharp and obvious, it becomes increasingly difficult to maintain such a distinction as the two groups are traced downwards to ever simpler forms, until they merge in an assemblage of organisms which partake of the characteristics of both kingdoms. Of the Protozoa certain groups are distinctly animal in their chemical activities or metabolism, in their mode of nutrition, and their locomotive powers; while in others it is very difficult to draw a distinction between them and the lower fungi, making it extremely difficult to separate sharply the Protozoa from the Protophyta, the lowest animals from the lowest plants, and therefore the term *Protista*, first introduced by Professor Haeckel, is now generally applied to designate these lowly forms of life, organisms which do not consist of an aggregation of differentiated cells.

A large number of the Protozoa resemble Amœba in the possession of pseudopodia, or false-feet, and these pseudopodia-bearing organisms constitute one of the great divisions or classes into which the Protozoa are divided—the class **Rhizopoda.**[1] But it is only a comparatively small proportion of these Rhizopods which, like Amœba, possess comparatively short, blunt pseudopodia, and they are consequently grouped together by this natural distinguishing feature to form one of the leading divisions

[1] Greek, *rhiza*, a root; *pous*, a foot.

or orders of the Rhizopoda—the order **Lobosa,** of which Amœba is one of the simplest.[1]

Some of the Lobosa differ from Amœba in the possession of a comparatively dense outer coat, forming a shell or test enclosing the protoplasm. One of these, called **Difflugia,** is fairly common in fresh water, and collects minute sand grains to form its flask-shaped test, the particles being agglutinated together. While the bulk of the protoplasm of Difflugia is contained within the interior of this curious test, the organism pushes out comparatively long pseudopodia.

Equally interesting, and also a commoner member of this group, is **Arcella,** an organism which has a convex, transparent shell of a tough material, said to be *chitinoid* from its resemblance to chitin, a horny substance such as we find the integument or outer skin of insects composed of. This transparent shell of Arcella is convex on one side, flat on the other, and in the middle of the flat surface there is a rounded opening through which the pseudopodia are protruded.

All the other Rhizopods differ from the Lobosa in having their pseudopodia in the shape of long, slender threads. The **Foraminifera** have these thread-like pseudopodia, and form a most interesting order, the members of which chiefly inhabit the sea, and, with a few exceptions, are provided with tests of the most varied and exquisite shapes, composed of carbonate of lime, or of cemented particles of sand. D'Orbigny first described the Foraminifera as minute cephalopods or cuttlefish, from the resemblance of the shells of some species to the Pearly Nautilus, and used the name Foraminifera to express the fact that the chambers of their shells communicated by pores, and not by a tubular siphon as in the nautilus. Their true nature as Protozoa was elucidated later, thanks to the careful and laborious investigations of Williamson, Carpenter, Dujardin, and Max Schultze.

That the Foraminifera are of very ancient origin we realise

[1] The Animal Kingdom is divided into phyla (sub-kingdoms), the phyla into classes, the classes into orders, the orders into families, the families into genera, the genera into species, while the species themselves are assemblages of individual animals agreeing with one another in certain constant characters. Thus, in terms of classification, we should describe the Amœba as follows:—Kingdom—animalia. Phylum (sub-kingdom)—protozoa. Class—rhizopoda. Order—lobosa. Family—amœbæ. Genus—amœba. Species—amœba proteus.

when we come to seek for their fossil remains in the rocks, for then we find that they range in geological time from the Lower Cambrian strata to the present day. The beautiful chalk cliffs that form a natural bulwark along many miles of the English coast, and the noble North and South Downs, consist almost wholly of the fossil remains of Globigerinids, while another species of Foraminifera, the Nummulites, have contributed largely to the composition of the great Eocene limestones, and are the chief constituents of the stone that was used in the building of the great Egyptian pyramids.

The species of Foraminifera to be found between tide marks on the seashore, and extending to the deep water beyond, are very numerous, and may be collected from the surface of the sand and mud left exposed by the receding tide, and upon the fronds of the seaweeds in the pools. Some may be met with in the brackish waters of estuaries; some are only to be found at various depths of the sea, or living among the bottom ooze; while others again float freely at or near the surface of the sea, and form at times a considerable proportion of the surface Plankton.[1]

Such pelagic [2] forms as **Globigerina,** and its allies, have the surface of their shells extended by extraordinarily delicate spines, which not only help to prevent the organisms from sinking, but also permit the protoplasm protruding from the mouth and fine holes in the shell to form a curious bubbly film between them, and to stretch out long, fine threads for the capture of food. On the death and decay of the protoplasm of these buoyant Foraminifera, their shells gradually sink to the bottom, losing in their passage downwards their more readily soluble delicate spines, and at last accumulating at depths where their more solid calcareous parts form a light oozy mud termed "Globigerina-ooze." At depths between 1,000 and 2,000 fathoms, on the floor of the Atlantic, great beds of this Globigerina-ooze, or modern chalk, are forming to-day in just the same way as the chalk cliffs of England were formed on the floor of a sea during a past geological age.

The shells of the Foraminifera are in many species composed of carbonate of lime; in one group, called the Arenaceous Foraminifera, the shells are composed of foreign particles, such as sand

[1] From a Greek word with the meaning "that which is drifted."
[2] Pelagic—buoyant, floating at whatever depth found.

grains, cemented together, while in certain fresh-water forms the shell is chitinoid. In all cases the shell at first has but a single chamber, and in some species persists as such throughout the life of the organism; but the general tendency is for the number of chambers to increase, with the result that they assume the most varied forms. Indeed, as Dr. Carpenter wrote in reference to the Arenaceous Forams, "There is nothing more wonderful in Nature than the building up of these elaborate and symmetrical structures by mere jelly-specks, presenting no traces whatever of that definite organisation which we are accustomed to regard as necessary to the manifestations of conscious life. The tests (shells) they construct when highly magnified bear comparison with the most skilful masonry of man. From the same sandy bottom one species picks up the coarsest quartz grains, unites them together with a ferruginous cement, and thus constructs a flask-shaped test, having a short neck and a single large orifice; another picks up the finer grains, and puts them together with the same cement into perfectly spherical tests of the most extraordinary finish, perforated with numerous small pores disposed at pretty regular intervals. Another species selects the minutest sand grains and the terminal portions of sponge spicules, and works them up together—apparently with no cement at all, but by the mere laying of the spicules—into perfect white spheres like homœopathic globules, each showing a single-fissured orifice. And another, which makes a straight, many-chambered test, the conical mouth of each chamber projecting into the cavity of the next, while forming the walls of its chambers of ordinary sand grains rather loosely held together, shapes the conical mouths of the chambers by firmly cementing together the quartz grains which border it."

An examination of a number of the shells or tests of different species of Foraminifera will show that while in some the shell has a wide opening on the exterior, in others this large opening is not present, its place being taken by numerous minute pores scattered over the surface of the shell: distinctions at one time used for the purpose of classification. Thus the Foraminifera were formerly classified, according to the structure of the shell, into Vitreous or Perforate, Porcellanous or Imperforate, and Arenaceous; but this classification is now considered too artificial, as it separates apparently adjacent forms. Brady, who described

the Foraminifera of the *Challenger* Expedition, has classified them in ten families.[1]

In the living Foram the bulk of the protoplasm is enclosed within the shell, though part of it streams out from either the large opening or from the numerous minute pores, in slender, radiating, thread-like pseudopodia, which sometimes join and form a living network. Diatoms, particles of animal or vegetable matter, organisms even more minute than the Foram itself, may become captured in the net and engulfed in the protruded protoplasm, and the soluble parts dissolved and assimilated, after the manner already described in connection with the Amœba. Soon after the first simple shell has been formed a little mass of protoplasm begins to project through the single large opening, or through the scattered pores, as the case may be, and, increasing in size, becomes enclosed in a shell like the original one, but generally a size larger, and firmly connected with it, the cavities of the two communicating with each other through the original opening or pores. This process may be repeated again and again, until, in place of a single speck of protoplasm enclosed in a single shell, a composite structure has been built up, composed of many particles of protoplasm, each having its own nucleus, each enclosed in a shell, and all the shells firmly united together; while the whole of the particles of protoplasm are in continuity through the apertures of communication.

Although the shells of a large number of different species have been most carefully described, there is need for further investigation into the processes of reproduction of the Foraminifera, but multiplication by fission appears to be most typical. A method of reproduction has been observed, in which the protoplasm inside the shell divides up into a number of particles, and each of the minute bodies so formed, instead of possessing pseudopodia, has a single delicate flagellum or lasher, by means of which it moves about. In the more typical fission process the nucleus may divide into several parts, and round each of these products of nuclear division a little mass of protoplasm gathers, and in this way young individuals are formed, which in due course become enclosed in shells and liberated from the parent.

[1] The name-giving types are Gromia, Miliolina, Astrorhiza, Lituolina, Textularia, Chilostomella, Lagena, Globigerina, Rotalia, and Nummulites.

The **Radiolaria** are marine Protozoa, well known to most amateur microscopists on account of their extremely beautiful skeletons, formed of silica, which are very favourite objects for exhibition under the microscope. While present in all seas, and in every latitude, living at the surface, at varying depths, and near the bottom, the Radiolaria are most numerous in tropical seas, and their siliceous[1] skeletons form a deposit or Radiolarian ooze at depths of 2,000 to 3,000 fathoms. Like the foraminifera, their history can be traced far back in the records of the rocks, their fossil skeletons occurring so remotely as the Cambrian strata, and in each succeeding geological epoch.

The living Radiolarian has the protoplasm divided by a perforated membranous sac (called the central capsule), into a central mass surrounding the nucleus, and an outer layer from which the slender thread-like pseudopodia are protruded. The nucleus contained in the enclosed or *intra-capsular protoplasm*, as it is termed, is always at first single, but later may divide again and again. The skeleton, usually composed of silica, may be a globular, conical, star-shaped, or disk-shaped perforated shell, frequently supported by spines radiating out from the centre, or may consist of loosely woven needle-like spicules; while some Radiolaria have the skeleton composed of a chitinoid substance called *acanthin*. Reproduction takes place by simple binary fission, and in some species by spore formation, in which the protoplasm contained in the central capsule breaks up into small masses which become flagellate spores or flagellula.

When we examine a living Radiolarian under the microscope, we shall see some minute yellow cells embedded in the protoplasm, which are living unicellular plants. These minute, simple plants are microscopic algæ, called *Zooxanthella*, and multiply by binary fission in the protoplasm of the Radiolarian, to whom they are of considerable benefit. In fact, we have here an example of that intimate association between two living organisms, to which the scientific term *symbiosis*[2] is applied. Now, during the process of respiration the Radiolarian is continually taking up oxygen from the surrounding water and giving off

[1] Latin, *silex*, quartz or flint; used for the kind of mineral forming the siliceous spicules of sponges, of Radiolarians, and the frustules of diatoms.

[2] Symbiosis, from the Greek, meaning "living together."

carbon dioxide, which it cannot work up into food products, as it is destitute of chlorophyll, the green colouring matter present in all green plants. The minute plant, on the other hand, under the action of light and by the presence in its tissue of chlorophyll bodies (*Chloroplastids*) can utilise the carbon dioxide for nutrition, the carbon being used for the building up of such compounds as starch and sugar, while the oxygen is liberated. Here, then, is an association beneficial to both organisms, and in this symbiosis existing between the Radiolarian and the alga Zooxanthella the latter benefits the former, contributing to its respiration by the oxygen which it gives off, and to its nutrition by the sugar and starches which it forms, while the Radiolarian supplies the carbonic acid and other substances necessary to the alga.

Diatoms are also found sometimes living symbiotically in the protoplasm of certain species; while an amphipod crustacean (Hyperia) has been observed as parasitic on colonial forms. Such colonial forms, which may attain considerable size, and float freely in the sea, are produced by the original central capsule dividing again and again, thus giving rise to a number of central capsules which remain embedded in a firm, gelatinous substance.

Mention must be made of the **Proteomyxa,**[1] a division of the Protozoa chiefly of interest to the specialist, and containing a number of somewhat obscure forms which cannot well be placed under the Rhizopoda. Very little is known about the life-history of these organisms. In many instances only one stage has as yet been observed, but it seems probable, according to our present knowledge, that most, if not all, at some stage, form cysts or spores. The spores escaping from such cysts may have pseudopodia like Amœba, when they are called *Amœbulæ*, and they may be furnished with one or two flagella. To this group belongs the Protamœba of Professor Haeckel, an organism more primitive than Amœba, for it is without any definite nucleus or contracting vacuole, and is found, like Amœba, living in both fresh and sea water.

A number of the Proteomyxa are parasitic upon fresh-water algæ, at least at one stage of their life-history, and one species is known to occur in the muscles of the domestic pig, but apparently without causing any harm to its host. The only species that is at present recognised as of any economic importance, and in some

[1] Greek, *prōtos*, first; *myxa*, mucus.

years causes very serious loss to the agriculturist, is *Plasmodiophora brassicæ*, which attacks the turnip and cabbage crops, producing the disease popularly known as "Fingers and Toes," "Anbury," or "Club-root." The name *Plasmodiophora* has reference to the slime-like character of the organism, and its resemblance to the so-called "Slime-fungi," or Myxomycetes, which are now generally included as Protista.

The roots of cabbages, turnips, cauliflowers, and other allied plants are frequently to be seen greatly distorted and deformed by swellings of varying size and shape, the result of the presence of Plasmodiophora in the root-tissues, while the plants present a miserable, stunted, starved appearance. If a carefully cut section from one of these diseased root-swellings be examined under the microscope, it will be seen that not only are the vascular bundles or strands of woody tissue displaced and altered, but that many of the cells of the tissues are enormously overgrown, and their contents quite different from those of normal, healthy cells.

Some of these giant cells will be seen to be filled with a semi-translucent, granular, foamy mass of protoplasm, which undergoes slow movements, while the embedded granules are constantly changing their position. The cell is, in fact, tenanted by a plasmodium [1] consisting of a translucent mass of protoplasm containing water-vacuoles, oily drops, granules, etc.

Other giant cells will be seen to be packed with minute, sphere-shaped spores. These spores become scattered in the soil as the diseased roots of the host-plant rot. Under suitable conditions of temperature and moisture the spores swell, rupture, and tiny protoplasmic organisms possessing a nucleus and a single flagellum make their escape into the surrounding soil. These penetrate into the roots of the seedling cabbages or turnips, probably gaining entry by the root-hairs, in much the same way as the protoplasmic zoospores of *Pythium*, the fungus which causes "damping-off" of seedlings. Having obtained entry into the cells of the root, the Amœbulæ lose their flagella, soon increase in size, and their nuclei divide.

The tissues of their host once entered, the Amœbulæ commence a battle with the living protoplasm of the cells for possession,

[1] Plasmodium, Plasmodia—derived from the same root as protoplasm, and referring to the protoplasmic nature of the organism.

The result of this irritant activity of warring life within the cells is to attract greater supplies of available food materials, so that the growth of the cells becomes abnormally accelerated, producing a monstrous growth. The increased supplies of food material benefit the Amœbulæ at the expense of the cell-contents of the host-plant, and after a time neighbouring Amœbulæ fuse together and plasmodium-formation begins. The plasmodia so formed are capable of passing slowly from one cell to another, devouring their contents and increasing in size, while the ravaged tissues of the host-plant begin to disintegrate. Finally the plasmodia break up into extremely minute particles of protoplasm, which form into spherical spores.

The **Mycetozoa**[1] comprise a group of simple organisms now generally looked upon as primitive Protozoa, though at one time claimed by botanists as fungi, and chiefly of interest to the biologist. They are to be found living as composite, multinucleate[2] plasmodia upon the damp, mouldering walls of ancient cellars, upon rotting timber, the decaying haulms of beans, and similar vegetable matter, feeding upon the organic debris; while one, called *Fuligo varians*, or "Flowers of tan," is a large and conspicuous species inhabiting tan-pits, where it is sometimes a great pest.

The composite plasmodia are formed by the complete fusion of numerous units, or, in a few rare cases, by their close contact with each other. The margins of these plasmodia masses exhibit amœboid movements, slowly streaming out towards food particles and engulfing them, spreading out towards moisture and warmth, but withdrawing from concentrated light. A dormant encysted stage sets in as a result of scarcity of food, lack of moisture, or cold, enabling the organism as a resting spore protected by a surrounding cyst-wall to await the return of favourable conditions for renewed growth and activity. On the rupture of the cyst-wall, a swarm spore, which generally possesses a whip-like flagellum, makes its escape, and always eventually loses the flagellum, becoming like a little Amœba in appearance and habit; and in the uniting of these minute Amœbæ we have the formation of the composite plasmodia.

The **Sporozoa** are a class of the Protozoa to which in only

[1] Greek, *myces*, a fungus; *zoon*, an animal.
[2] Multinucleate, having many nuclei.

quite recent years scientific investigation has been closely applied; but since this class has been recognised to contain organisms which induce malarial fever in man, and various other diseases in man and animals, there has been no lack of workers, and much successful investigation has been carried out. To the researches of von Siebold, Kölliker, and van Beneden we owe our earliest accurate, though partial, knowledge of the class; while some thirty years ago Sir E. Ray Lankester began the study of those species which live in the blood, an epoch-making piece of biological investigation of unique and immense importance to mankind. The work begun by these pioneers has been carried on by Manson, Ross, Minchin, Grassi, Laveran, Blanchard, Léger, Cuénot, Schaudinn, and many other distinguished English and Continental workers. The result of the work of these numerous investigators has shown the Sporozoa to be of very widespread occurrence, exclusively parasitic in habit, and infesting the internal organs or tissues of animals belonging to nearly every class and order of the Metazoa.[1]

The greatest diversity of structural and developmental characters are exhibited by the Sporozoa, and there is a general, though not universal tendency for each species to be parasitic on a particular species of host, and to be confined to certain organs or tissues of that host. The effects produced by the Sporozoa upon the animals they infest vary greatly, in many cases, possibly in most, causing no apparent discomfort or injury to the health or vitality of their host, but in others producing most dangerous, not infrequently fatal diseases, and ravaging epidemics. Wide limits as regards size are reached by the different species, some being so minute that several can be contained in a single blood-corpuscle, while others, like the Gregarine Sporozoon (*Porospora gigantea*), parasitic in the lobster, are clearly visible to the naked eye.

Considered as a group, the Sporozoa will be found to possess in common certain very characteristic features. Thus food-vacuoles or contracting vacuoles are never present, the nutriment consisting of the juices of the host, and therefore always of a fluid nature, being absorbed by diffusion through the cuticle of the parasite's body; while, where flagella or pseudopodia are present they exist essentially as organs of locomotion and not of nutrition.

[1] From the Greek—many-celled or multicellular animals, as distinct from the Protozoa or unicellular animals.

The life-cycle typical of a Sporozoon may be divided into three main periods: the first chiefly the period of growth, during which the minute sporozoite, by the absorption of food from the host, is growing into what is termed the *sporont;* the second is the period of reproduction or multiplication, which is accompanied by conjugation, and the resulting formation of a large number of minute, often sickle-shaped germs, destined ultimately to spread the species; while the third is the period of rest, during which the parasitic germs pass out from the old host to effect, if circumstances are favourable, the infection of a new host.

Up to the present three modes of infection have been observed. The commonest, which may be called casual infection, takes place by the host accidentally swallowing the spores along with its food. The second, or inoculative, method is typical of the malarial parasites, and is effected through the agency of an intermediate host, such, for example, as the spot-winged anopheline mosquito. The third is a very rare type, that of hereditary infection, in which, as has been demonstrated in the silk-worm disease, caused by a sporozoon parasite called *Glugea bombycis*, the parasites penetrate the ovum of the host and produce spores there, which germinate and infect the new generation of the host.

It would be impossible here to describe all the numerous species of Sporozoa, their appearance, habits, and life-history; but on account of the far-reaching economic importance of their discovery, special mention must be made of those Sporozoa which are the cause of malarial fevers in man. To Laveran, a French medical man, we owe the discovery of the minute parasite in the red blood-corpuscles of man which is the cause of malaria, while Golgi demonstrated the coincidence of the stages of the intermittent fever with those of the life-cycle of the parasite in the human host which is the febrile cycle producing auto-infection (regularly recurring attacks of fever every one, two, or three days)[1] of the patient.

In the blood of the affected person the parasite passes through an asexual cycle, entering the red blood-corpuscle as an amœboid organism, and therein attaining its full size and becoming filled with granules of black pigment, which are probably a decomposition product of the red colouring matter (hæmoglobin) of the

[1] Termed, according to their periods, quotidian, tertian, and quartan fevers.

corpuscle. The nucleus of the parasite now divides repeatedly, after which the parasite divides into a number of spores and bursts the corpuscle, thus liberating the newly-formed spores and the black refuse-matter, which acts as a poison, producing chill, nausea, shivering, and fever in the patient. The liberated spores at once attach themselves, each to a fresh red corpuscle, and a repetition of the life-cycle ensues.

After the disease has persisted for some time, certain of the full-grown parasites, instead of dividing up, pass, as it were, to a period of rest as either round or blunt crescent-shaped cells (termed "half-moons"). These are sexual cells, which only develop further when the blood containing them is withdrawn from the human host. This sexual cycle of the parasite was discovered by Major Ronald Ross to take place in the gut of the spot-winged mosquito (*Anopheles*), which he has also proved to be the transmitting agent of the parasite of malaria from man to man.

When the Anopheline mosquito pierces the skin and sucks up the blood of a person suffering from malaria, it also sucks up a number of the resting sexual cells of the parasite, which at once begin to undergo a series of changes; they become spherical, and the males produce flagella-like sperms, which break away and fuse with and fertilise the female spheres or egg-cells. The fertilised cell takes on an active worm-like form, and partially pushing itself through the wall of the mosquito's gut, feeds on the insect's blood. It soon swells up, divides internally again and again, and becomes enclosed in a firm, transparent cell or cyst. Finally, the cyst-wall is ruptured, and the needle-shaped spores escape and accumulate in the salivary glands of the mosquito, passing out of the mouth of the insect when it stabs a fresh human victim, who thus becomes infected. It is only in species of *Anopheles* that the parasite can undergo its sexual development and the process of the production of needle-shaped spores, for if the sexual cells are swallowed by an ordinary gnat or mosquito of the genus *Culex* they are digested by the insect and destroyed.

These joint discoveries of the malaria parasite by Laveran, and of its sexual cycle in the gut of the transmitting agent, the spot-winged mosquito, by Major Ronald Ross, are of the greatest economic importance and far-reaching in effect. They rendered the cutting of the Panama Canal possible, and have

converted many a fever-haunted district into a healthy, prosperous neighbourhood. Wherever the Anopheline mosquito has been stamped out, malaria has disappeared, and the health, vigour, and prosperity of the people increased. The life-history of the Anopheline mosquito, and the methods employed for its extermination, will be dealt with in a later chapter.

The first **Sporozoa** to be closely observed and studied were the **Gregarines,** on account of their comparatively large size. They are to be found living in the internal organs of various insects, crustaceans, echinoderms, and worms, and the majority appear to exert no ill-effects upon their host, feeding upon the liquid food of the host as it exists in the intestine. In most species the body is rather elongated and flattened, in the species which infests the intestine of the so-called "meal-worm" [1] somewhat resembling an Indian club in shape. When about to multiply, the Gregarine contracts its body into a ball-shaped mass and becomes encysted. The nucleus and protoplasm within the cyst divide into numerous minute spores, which ultimately make their escape and grow into new Gregarines.

We have seen that in the course of their life-history some of the Protozoa we have had under consideration pass in the process of multiplication through a spore stage characterised by the presence of a slender lasher or flagella. In a great number of Protozoa, however, we shall find that this flagellate condition of the cell is not a transitory one, but is the permanent condition of the adult organism. These forms are included in the class **Flagellata** [2] of the Protozoa, and comprise a very heterogeneous assemblage of organisms, very interesting and very puzzling to the student, for in this, more than in any other class, those formal distinctions which are commonly drawn between the animal and vegetable kingdoms disappear. Nevertheless the organisms comprising this class possess in common certain characteristic traits of organisation, such as a single nucleus, one or more contractile vacuoles, and one or more flagella, which link them together. The vast amount of biological investigation which has been accomplished has greatly widened the field of knowledge concerning

[1] "Meal-worms" are the larvæ of *Tenebrio molitor*, a small beetle all too common in granaries and flour mills.

[2] The Flagellata as here described correspond to Bütschli's group of the Mastigophora.

these organisms, so that the old, and at times bitter, controversy as to whether such and such an order of the Flagellata should be placed among the unicellular plants, or among the Protozoa, is practically ended, Professor Haeckel's term *Protista* sufficiently describing their somewhat elusive character.

Living under varying conditions, the Flagellata exhibit various methods of nutrition. Some of the simplest forms live in liquids containing decaying organic matter, which they absorb through their surface ; [1] some engulf their food either amœba-fashion, or into a food-vacuole, or by a definite mouth ; [2] while others, owing to the possession of coloured plastids or chromatophores, which may be green, brown, or yellow, are able to manufacture their own food-supply, after the manner of plants.[3] Again, there are some species which, while possessing these chromatophores at one stage of their life, lack them at another ; or, as in the case of *Euglena*, an organism common in fresh-water pools, to which, owing to its presence in vast numbers, it often imparts a greenish hue, the same individual may combine the characteristically animal (holozoic) with the typically vegetable (holophytic) mode of nutrition, during the course of its life.

The Euglena has a spindle-shaped body, with, at the blunt end, a depression or gullet, from the inner surface of which arises a long flagellum used for locomotion. The greater part of this microscopic organism is green in colour, due to the presence of the characteristic vegetable pigment, chlorophyll, and contains grains of a carbohydrate allied to starch, called *paramylum*. A bright red speck of pigment is also noticeable, which is thought probably to function as a light-perceiving organ, a sort of very rudimentary eye. The whole body is invested by a very thin skin, or cuticle, so that, though the Euglena does go through certain worm-like movements of expansion and contraction, it is incapable of the free and ever-changing pseudopodial movements of amœba. By means of its chlorophyll the Euglena is able to decompose the carbon dioxide of the air dissolved in the water of the pool in which it is living, and, by assimilating the carbon,

[1] The Saprophytic method of feeding, which is also characteristic of certain fungi.

[2] Holozoic.

[3] Holophytic. It is by means of the microscopic green chlorophyll-bodies or plastids that the higher plants, under the influence of sunlight, manufacture their food-supply, drawing the carbon dioxide from the air.

set free the oxygen; while by absorbing the nitrogen and other elements in the form of mineral salts in solution in the water, it is thus nourished like a typical plant. At the same time the movements of the flagellum have been seen to create a current by which minute fragments of organic matter are propelled down the gullet into the soft internal protoplasm, where they are digested, so that a characteristically animal mode of nutrition also takes place.

Among the Flagellata are to be found the bulk of those marine organisms which form a very large proportion of what is called the *micro-plankton* of the sea, and which may be said to constitute the primary food-supply of the higher forms of marine life. Therefore, investigations which will help to throw light upon their life-histories, and the conditions which are most favourable to their development and multiplication, will be of the greatest value in the consideration of many problems connected with fishery questions, and the successful rearing of marketable marine fishes in the early stages of their lives.

The marine **Dinoflagellata,** which chiefly compose this floating plankton, are in many instances phosphorescent, lighting up the sea on a dark night with their wonderful glow so that every wave seems to break in a cascade of silvery light. They are characterised by the presence of two flagella: one is conspicuous and filiform, arising in a longitudinal groove extending its whole length and projecting beyond the animal; the other also arises in the longitudinal groove, but is band-like in appearance and extends along a somewhat spiral transverse groove from which it never protrudes during life, but in its movements resembles a girdle of cilia—a deceptive appearance which led to these organisms formerly being called *Cilioflagellata.* The true character of this second flagellum was discovered by Klebs. Multiplication usually takes place by oblique division of the body into two dissimilar halves, each half undergoing a peculiar growth to reconstruct the missing portion.

Most of the Dinoflagellata possess a complete membrane or cuirass of cellulose, the typical material of the cell-walls of plants, usually hard, with distinctive form and markings, and divided into plates. *Ceratium,* which is remarkable for the horn-like backward prolongations of its lower end, is an interesting and abundant genus in the sea.

Extremely abundant round our English coasts, and one of the chief causes of the phosphorescence of the sea on summer nights, *Noctiluca miliaris* is a familiar object to most students of the microscope. It belongs to the sub-class **Cystoflagellata**, and has a very wide geographical distribution. Noctiluca is quite a giant Flagellata, measuring about 1 mm. or more in diameter. In shape it is something like a peach, having a similar indentation or cleft on one side, from which arises the large, stout, striated flagellum. Two lip-like prominences may be seen in front of the base of this large flagellum; one, transversely ridged, and slightly firmer than the other, is called the "tooth." At the junction of these two prominences is a second and minute flagellum, the cilium, and behind these is the oval mouth, through which food is absorbed. The phosphorescence glows with a bluish or greenish light when the little Noctiluca is disturbed, disappearing when the cause of irritation ceases.

One large group of Flagellates inhabiting both fresh and salt waters, and called Collared Monads (**Choanoflagellata**) are of particular interest as probably representing a link or transition towards the sponges. The members of this group are characterised by a remarkable outgrowth of the protoplasm around the base of the single flagellum, giving to that organ the appearance of being surrounded by a transparent collar. This collar is contractile, and its movements appear to produce currents in the water which carry the organic particles of matter upon which the monad feeds down to the soft protoplasm between the base of the flagellum and that of the collar, when a food-vacuole is formed for their ingestion. The ordinary mode of multiplication among these Collared Monads is by longitudinal fission extending up through the funnel or collar.

Belonging to this group is a colonial form called *Proterospongia*, which secretes a gelatinous investment by which it becomes attached to solid bodies. According to the observations of the late Mr. Saville Kent, the central members of the colony retract their collar, lose their flagellum, become amœboid, finally undergoing brood-formation to produce minute zoospores, comparable to the spermatozoa of a sponge. A colony of Proterospongia strongly recalls many of the characteristics of the true sponges, and indeed has been regarded as a transition towards them, for

the flagellate, nutritive cells of the sponges are provided with a collar similar to that of the Proterospongia and its allies, a form of cell which does not exist in any other group of the Metazoa.

If we dip a collecting bottle into a pond or clear pool during the summer months, we may sometimes see, on holding the bottle up to the light, that its fluid contents is peopled by a number of very small, brightish green spheres, which roll about through the water in all directions, and which are specimens of the interesting *Volvox globator*. Each hollow sphere represents a colony composed of a single layer of individual cells, each contained in its own cell-wall or capsule, united together by protoplasmic bridges, the entire colony numbering from 1,500 to 22,000 cells. Botanists and zoologists in the past fought long for the sole possession of the Volvox, the former claiming it as belonging to the algæ, the latter equally firmly claiming it as a flagellate colonial Infusorian; for the Volvox has characteristics both vegetable and animal. Its possession of flagella, contractile vacuoles, and eye-spots attest to its animal properties, while the presence of chromatophores, starch granules, and proteid granules (pyrenoids) demonstrate its vegetable affinities.

The life-history of this remarkable Protista has many interesting points, which seem to foreshadow the more complex life of the Metazoa or multicellular animals. In that half of the Volvox hemisphere which is posterior in swimming, some five to eight larger cells can be seen, which, as they grow, segment to form new colonies. At first each young colony is a plate, but as its cells multiply the plate bends up and finally forms a hollow sphere. When at last the parent sphere ruptures for the liberation of the young colonies, it sinks to the bottom of the pond and dies. This is the first example of a progressive change leading to the introduction of death as a constant phenomenon, as it occurs in the higher animals.

The ordinary Protozoon, as we have seen, is a single cell, and forms no body. It divides, and in this way multiplies, but the products of division go asunder. In most Protozoa division takes place without any loss, there is no distinction between parent and offspring, there is continual self-recuperation, and as there is no body formed there is no death. Now in Volvox, the cell which

starts one of these colonies divides, and the products of division do not separate, but remain connected as a loose body of numerous cells. In this hollow spherical cluster of cells, some are set apart and eventually liberated as reproductive cells which will start new colonies; while other cells surrender their power of fission so inherent in the Protist cell, becoming vegetative cells, the supply of food material due to their living activities going to the nourishment of the reproductive cells. It is these vegetative cells which perish when the ruptured sphere sinks down into the mud on the floor of the pond.

Under certain conditions the reproductive cells may give rise to two distinct types of cell; one small, yellow in colour, rod-like, and with two flagella; the other an enlargement of the original cell, which has become enriched at the expense of neighbouring vegetative cells. Conjugation takes place between these distinctive cells; the flagellate forms escaping, swim about freely, and conjugate with the large motionless cells to form a zygote, which, after a period of rest, divides and gives rise to a new colony.[1]

Here, then, we find a differentiation of reproductive cells in an active flagellate male cell, a passive richly stored female cell, each functioning in the same manner as the active and passive male and female reproductive cells of the higher animals, and by their union or conjugation producing a similar result.

Of recent years the **Hæmoflagellata** or **Trypanosomes** have attracted a great deal of attention, on account of the appalling destruction of human life from diseases set up by the presence of these organisms in the blood system. Like the malarial parasite already described, these Hæmoflagellates are transmitted to man through the agency of certain blood-sucking insects, but the disease set up, on account of its peculiarly fatal character, is far more appalling than malaria. Sleeping sickness, or human trypanosomiasis, as this terrible disease is called, appears to have existed among the natives of the West African coast from the remote past, and to occur, though rarely as a very serious scourge, throughout tropical West Africa. But from there it has crept

[1] When two individual cells come together and become completely fused, the process is known as *Conjugation*, the body formed by the union of the cells being known as a *Zygote*.

up the newly opened trade-roads of the Congo basin and spread through Uganda into British East Africa.

"In the west of Uganda, since the disease was first noticed, in 1901, more than 200,000 people have died of it. Out of 300,000 living on the shores and islands of the great Lake Victoria Nyanza less than 100,000 remain, the rest having perished from sleeping sickness or human trypanosomiasis. In every case the disease has been transmitted from one victim to another by certain species of true flies." [1]

The organism which by its presence and multiplication in the blood is the cause of this terrible disease is the *Trypanosoma gambiense*. Other Trypanosomes are the cause of various more or less fatal diseases in domestic animals, such as surra, a disease which affects horses in India; nagana or tsetse-fly disease among cattle and horses in South Africa; dourine, which attacks horses and mules in Northern Africa; and the *mal de caderas* of horses in South America.

Members of all the chief classes of vertebrates, with the exception of the Cyclostomes [2] (which may prove on further investigation not to be immune), harbour these parasites, mammals, birds, and fishes furnishing the greater number of hosts, though neither amphibians nor reptiles are exempt.

In the consideration of the occurrence of these Trypanosomes, it is necessary to draw a careful distinction between true or natural hosts and strange or casual hosts, for in the case of the natural host a condition of mutual toleration has been reached, owing to the long-existing association between parasite and host. The entry of a Trypanosome into a host which has never been previously liable to its invasion, however, usually produces serious, if not fatal, results, owing to the casual host being unaccustomed and unadapted to its presence.

Recent research all points to the probability that every pathogenic or lethal Trypanosome has some tolerant indigenous wild animal host which serves as a latent source of supply from which strange animals entering the district may become affected; the

[1] From my lecture on "Industrial Entomology: The Economic Importance of a Study of Insect Life," delivered before the Royal Society of Arts, May 20th, 1908, and published in the Society's Journal, Vol. lvi., p. 688.

[2] The Cyclostomata (literally "round mouths") are a class of vertebrates separated from the true fishes by certain fundamental divergences. The hag-fish and lamprey are types of the two orders into which the Cyclostomes are divided.

parasite is almost invariably transmitted from the natural passive hosts to the newly introduced animal by certain species of blood-sucking invertebrates (insects and leeches). It was in this way that the recently introduced cattle and horses of the settlers in South Africa were attacked by nagana or tsetse-fly disease, as they passed through belts of country inhabited by herds of big game and the blood-sucking insects which prey upon them; for it has been shown that the nagana parasite (*Trypanosoma brucii*) is almost certainly to be found in the blood of the native buffalo, the gnu, and the koodoo. Nagana is transmitted from one animal to another in South-east Africa by the blood-sucking tsetse-fly, *Glossina morsitans;* while *Trypanosoma gambiense*, the cause of sleeping sickness, is conveyed from man to man by another tsetse-fly, the *Glossina palpales*.

Trypanosomes possess one or two flagella, both originating close together at or near the anterior end of the body, one being free and directed forwards, while the other turns back and is attached by means of an undulating membrane to the side of the body for the greater part of its length, its free end being directed posteriorly. Should only one flagellum be present, it appears to be invariably attached in this manner. Reproduction appears most frequently to take place by binary longitudinal fission, though multiple division or segmentation also occurs. There is need for much further investigation of the life-cycle of these parasites, as comparatively little is known in most cases about the true alternate host (transmitting agent), in which definite phases of the life-cycle, including probably sexual conjugation, take place. Thanks, however, to the researches of Minchin, Schaudinn, Laveran, Bruce, Plimmer, Woodcock, and other well-known protozoologists, great additions have been made to our knowledge of the Hæmoflagellates and of the hosts, passive and casual, which they inhabit.

The **Infusoria** form a complex group of the Protozoa, and were originally grouped under this title from their frequently inhabiting fluids containing an infusion of organic matter. Their food consists chiefly of microscopic forms of animal and vegetable life even more minute than themselves, and of particles of organic matter that may be floating in the water they inhabit; many thrive in water which contains putrefying matter, feasting upon

the swarming bacteria present in such media. While the majority are inhabitants of fresh water, a considerable number are marine; others are entozoic in their habits, living in the intestines, bladder, and blood of higher animals. Although these are sometimes spoken of as "Parasitic Infusoria," it is doubtful if the term is accurately applied, for, so far from gaining their living at the expense of their host, they do not appear to feed upon anything except such substances as would otherwise be ejected from the body; therefore it would seem highly probable that their presence is really beneficial to their host.

They are grouped into two sub-classes: (1) the **Ciliata,** the members of which are either free or fixed forms, with cilia disposed in tracts or bands upon the body for purposes of locomotion and the capture of food; and (2) the **Acinetaria,** which are fixed sedentary forms possessing suckers or tentacles, and bearing cilia only during their active youth. Reproduction in the simplest forms takes place by transverse fission, while in the higher forms it is accomplished by longitudinal fission and by encystment and spore-formation. Encystment may also be purely a resting stage, from which only one individual escapes. Such resting cysts are capable of resisting the effects of dry air for a considerable time, and in this way periods of long drought are tided over, the cyst remaining dormant in the dried mud at the bottom of the pond or pool, until the rains once more restore the supply of water. In the same way such resting cysts may be carried away by the wind from their dried-up homes and transported for considerable distances, always with the possibility of falling into other waters.

We can very readily become familiar with the appearance of some of the Ciliata, by examining under the microscope a drop of water taken from any stagnant pool. This will be almost certain to contain a number of the so-called "Slipper-animalcules" (*Paramœcium*), moving about in the most active manner. Their bodies are long, narrowish, bluntly-pointed at one end, and more sharply at the other, so that the general outline of the body somewhat resembles the sole of a slipper. They are flat, and with a little attention we shall be able to make out on the ventral side of the body a large oblique depression, the buccal groove, leading into a short gullet which in turn ends in the soft internal protoplasm. The body is covered by small, delicate lashers, or

cilia, arranged in longitudinal rows, and these cilia are kept in an incessant to-and-fro vibration by means of which the Infusorians move about and obtain their food. The cilia in the neighbourhood of the buccal groove produce currents in the water, in which minute particles of organic matter are caught and carried down the gullet into the soft protoplasm, where they become surrounded by a globule of water or "food-vacuole"; they circulate through the protoplasm, and the soluble parts become gradually digested and assimilated; the insoluble and effete matters are ejected at a definite anal spot.

Several of these "food-vacuoles" may be seen in the body of the Slipper-animalcule, and also two large contractile vacuoles, one at each end of the body, which keep up a regular pulsation of expansion and contraction. There are two nuclei, one a comparatively large ovoid body, called the *meganucleus;* the other, closely applied to the meganucleus, is a small rounded body, and is called the *micronucleus.*

Multiplication in the Slipper-animalcule takes place by transverse fission, the nuclei dividing prior to the division of the body. This process of multiplication, however, cannot be continued indefinitely, and there comes a time when the Paramœcium must conjugate with another of its species or perish. In this process, two Paramœcia become applied by their ventral surfaces, but do not actually fuse together; then their meganuclei break up and disappear, while an interchange of the micronuclei of the conjugating individuals takes place, with the result that each develops a new mega- and micro-nucleus, partly from the substance of its own micronucleus, partly from that of its partner.

It will be observed that in Paramœcium we have something more complex than a mere sexual cell, for of its whole body it is only a very small part, the micronucleus, which functionally conjugates; we therefore find an advance in the complexity of the individual and towards the differentiation of sex, for the micronucleus is only to be compared with the nucleus of the sexual cells of the Metazoa. Gradually, step by step, we may trace the evolution of the sexes. In the free-swimming Ciliata, such as the Paramœcium we have just been examining, there appears to be no distinction of sex into definite male and female form, all the individuals in which conjugation is taking place being of exactly

the same size and structure; here the outstanding feature is the interchange of the micronuclei, which exerts a revivifying or fecundating effect upon the conjugating individuals. In the case of a sedentary Infusorian called *Spirochona*, which is to be found attached to the gills of Gammarus (one of the Amphipod crustacea), no external features of differentiation have been observed, and possibly do not exist between individuals capable of conjugating with each other. Two apparently identical individuals will bend towards each other and join by their oral surfaces, one of the individuals ultimately separating from its basal support and becoming partially or wholly absorbed by the other one, thus ceasing to exist as an individual.

In the graceful *Vorticella* or Bell-animalcule and some of its allies, the difference between individuals that can conjugate is well marked prior to the process taking place. The Bell-animalcule is a very common inhabitant of ponds, attaching itself to the leaves and stems of the submerged vegetation by a slender spirally contractile stem. Its body is slightly oblong, shaped like a bell or wine-glass, the slender stem of which forms the contractile stalk. The rim of the bell encloses an elevated disc of protoplasm, between which and the rim on one side is the opening of the mouth leading to the gullet. Cilia run in a spiral band round the rim of the bell, round the edge of the disc, and down into the gullet, producing active currents in the water by their motion, and so capturing and carrying down into the gullet particles of organic matter upon which the Infusorian feeds. Multiplication often takes place by division of the bell-body longitudinally, one of the halves being set free furnished with an additional posterior circlet of cilia by means of which it swims actively about for a time, eventually becoming attached to some base by a spirally contracting stalk. After division, the remaining undetached individual may rapidly divide into eight small units—male cells—which, becoming detached, swim away by means of their cilia, but do not ultimately settle down as the normal sedentary stalked form. The sedentary stalked form, which may be called the female, is not capable of conjugating with another individual of the same kind, but only with one of the small free-swimming forms (males) that are periodically produced. Nor can these free-swimming forms conjugate with each other, but

only with the sedentary stalked form; so that in Vorticella we have the sexes distinctly differentiated in form and habit prior to conjugation.

In the foregoing outline sketch of the Protozoa, attention has been drawn, so far as space and the avoidance of very technical questions would permit, to the most interesting points concerning these remarkable organisms. In the Amœba we have had an example of a very primitive form of life, of an organism complete in itself, though of comparatively simple structure, capable of carrying on all the processes of life—the capture and assimilation of food, movement, growth, multiplication—without the development of any special organs for carrying out these vital functions, excepting, of course, the part which the nucleus plays in its multiplication by binary fission. And we have seen the comparative immortality of these organisms. In the fusing or conjugation of similar cells, identical in appearance, we may trace the dawn of sex and the gradual differentiation into the typical active male and sedentary female cells (sperm and ovum); while in the colonial form of Volvox we caught a glimpse of the introduction of death as a constant phenomenon, through the modification to special ends of certain cells. Of the economic importance of the study of certain groups of the Protozoa, the malarial parasite and the Trypanosome of sleeping sickness are sufficiently impressive examples. Indeed, the story of the discovery of the malarial parasite, of its sexual cycle within the gut of the spot-winged mosquito, and the means that discovery has placed in our hands of successfully combating one of the most dreaded tropical diseases, and of thereby bringing health and prosperity to wide regions of country, should eloquently convince even the most hardened sceptic of the inestimable value of biological research.

CHAPTER II

THE SPONGES

For a long time the Sponges, or **Porifera**, were a great puzzle to naturalists, and were bandied about from the animal to the vegetable kingdom and back again. Thus we find Aristotle concluding that they were lowly forms of animal life bearing a certain resemblance to plants; while old Gerard, writing in the sixteenth century in his famous "Herbal," would have us believe them formed of "a certain matter wrought together of the foame or froth of the sea." So late as the middle of the eighteenth century it was suggested that Sponges were really formed by certain marine worms as shelters from their foes, the spongy mass being "merely a nidus or secretion." This was contradicted by Ellis (1765), who, in the course of his examination of a living Sponge, "plainly perceived the small tubes inspire and expire," and concluded that the "openings of the branched tubes are the mouths by which it receives its nourishment and discharges its excrements."

It was not until after the fundamental discoveries of Robert Grant, in 1825, that the right of the Sponges to a place in the animal kingdom was universally admitted. Even then they were at first relegated to the Protozoa, and from the discovery of the resemblance of their collared-cells to the flagellate Infusoria, were for some time regarded as mere aggregates of those Protozoa. Since then, however, the very precise and thorough investigations which have been carried out concerning the structure and embryology of the Sponges has left little doubt as to their real character as primitive Metazoa or multicellular animals.

Marking, as it does, an epoch in the scientific investigation of the Sponges, Grant's own account of his earliest observations is of the greatest interest:—"In the month of November last," he writes, "I therefore put a small branch of the *Spongia coalita*, with some sea-water, into a watch-glass, under the microscope

and, on reflecting the light of a candle up through the fluid, I soon perceived that there was some intestine motion in the opaque particles floating through the water. On moving the watch-glass, so as to bring one of the apertures on the side of the Sponge fully into view, I beheld, for the first time, the splendid spectacle of this living fountain vomiting forth from a circular cavity an impetuous torrent of liquid matter, and hurling along, in rapid succession, opaque masses which it strewed everywhere around. The beauty and novelty of such a scene in the animal kingdom long arrested my attention; but, after twenty-five minutes of constant observation, I was obliged to withdraw my eye from fatigue, without having seen the torrent for one instant change its direction, or diminish in the slightest degree the rapidity of its course. I continued to watch the same orifice, at short intervals, for five hours, sometimes observing it for a quarter of an hour at a time, but still the stream rolled on with a constant and equal velocity. About the end of this time, however, I observed the current become perceptibly languid; the opaque flocculi of fæculent matter, which were thrown out with so much impetuosity at the beginning, were now propelled to a shorter distance from the orifice, and fell to the bottom of the fluid within the sphere of vision, and in one hour more the current had entirely ceased." Although Grant suspected that these currents were due to the movement of cilia, he failed to detect them, and they were subsequently observed by other workers.

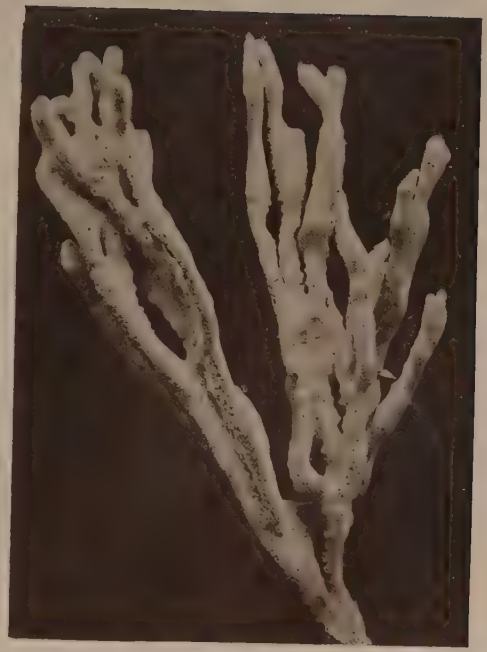
That we may gain some idea of the main characteristics of the Sponges, we will first examine a small, simple Sponge which is to be found attached to the rocks in deep pools on the shore at low-tide mark. This is the little Sycon Sponge (*Sycon gelatinosum*), which grows as a tuft of short, branching cylinders, about 2 or 3 inches long, all connected together at the base where the Sponge is attached to the rock. In its simplest form the body of a Sponge is shaped like a cylinder or vase, attached to a base at its closed end, and with the upper, free end open; so that Sycon may be likened to several of these single cylinders joined together at their base. If a portion of the Sycon Sponge be examined under the microscope, it will be seen that there are groups of minute openings—the inhalent pores—pretty evenly distributed over the outer surface, and that the free end of each branch or cylinder has a

slightly larger terminal opening — called the *osculum* — surrounded by what looks like a delicate fringe. If our specimen has been recently collected, and is therefore still in a vigorous condition, we shall be able to witness the same interesting sight as described by Professor Grant, particularly if we add a very small pinch of carmine powder to the sea-water in the vessel containing the Sponge. We shall then see how the very fine particles of the carmine powder appear to be drawn towards the sides of the branches, and to pass into the interior of the Sponge through the minute inhalent pores, only to be ejected by an outward current issuing from each large terminal opening, demonstrating that there is some motive power within the Sponge that produces an indrawing current of water through the minute inhalent pores (*ostia*) and an exhalent expelling current from the terminal openings (*oscula*).

How these incoming and outgoing currents are produced we can only discover by the aid of the dissecting knife and microscope. If, therefore, we cut longitudinally through one of the branches of the Sycon Sponge, using a sharp dissecting knife so as to cleave it cleanly from top to base, we shall see that the terminal opening (*osculum*) leads into a central passage called "the exhalent canal," which runs the entire length of the cylinder or branch, and joins the passages belonging to the other branches, where they unite at the base, so that there is a regular system of communication throughout the Sponge. Under the microscope we shall be able to see that the walls of these cavities are perforated by numerous fine apertures, called "the radial" or "flagellate canals." We shall also be able to make out that these flagellate canals run side by side with the incurrent canals, and actually communicate with them at certain points by small openings.

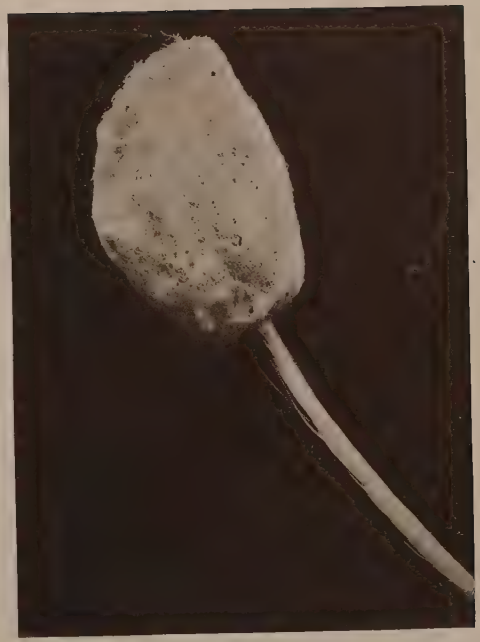
We shall now see that the incurrent canals end blindly at their inner extremities, and do not, as we might have supposed, communicate directly with the large exhalent canal; on the other hand, the flagellate or radial canals, while communicating with this central cavity, have no opening at the exterior, their outer ends terminating a little below the outer surface of the branch. Therefore the inflowing current of water, carrying with it particles of organic matter and small living organisms, enters through the

Leucosalinia blanca



A Branching Sponge

Venus's flower-basket sponge



Glass-rope sponge

incurrent canal, passes through the openings in the walls communicating with the flagellate canal, along which it travels to be expelled into, and finally discharged from, the large exhalent canal; and in this way a constant circulation of water is maintained throughout the Sponge.

The body of the Sponge is composed of three layers of cells, of which the outer layer is called the *ectoderm*, the inner layer the *endoderm*, and the middle layer the *mesoderm*. The outer surface of the Sponge and the walls of the incurrent canals are covered by a single layer of flattened, scale-like cells composing the ectoderm layer, while the endoderm lining the exhalent or paragastric cavity is composed of cells very similar in shape. Not so, however, the cells lining the radial or flagellate canals; their structure is quite different, and will require a higher magnification to be clearly seen. They consist of a close continuous layer of column-shaped cells, each terminating in a single long, slender lasher (*flagellum*), surrounded at its base by a delicate, collar-like, transparent upgrowth.

These specialised cells, with which the radial canals are lined, are of very great interest, because they are only to be found in the Sponges, and not in the tissues of any other animal belonging to the Metazoa. Each of these specialised cells, in addition to the collar-like upward expansion and terminal flagellum, has a nucleus and one or more vacuoles, so that it really very closely resembles a miniature collared-monad (*Choanoflagellate*) of the Infusoria. It is by the constant movement of the flagella of these cells that the water is drawn in from the incurrent canals, and apparently so similar are the movements of the collar and lashers to those of the collared-monads that particles of food are captured by those cells in just the same way; while the effete and insoluble matters are swept onwards by the lashers and discharged through the exhalent canal.

In the light of recent research, the evidence seems to point to the Sponges having developed from a collared-monad progenitor, through some such ancestral type as the colonial Infusorian *Proterospongia*, described by the late Mr. Saville Kent. The middle layer, or mesoderm, consists chiefly of a clear, jelly-like, greyish mass in which lie the skeleton or spicule and sponging-forming cells, and also certain curious cells called, from their

amœba-like movements, "wandering cells" (*Archæocytes*), and "capable of first performing elementary functions of digestion, distribution, and probably excretion, and later of becoming germ cells."[1]

The reproductive cells, the ova and spermatozoa, are also found in the mesoderm, the ova commencing their existence as cells closely resembling the amœboid ones, and chiefly distinguished by their large bladder-like nucleus and its large round nucleolus; while the oval-headed slender-tailed spermatozoa occur in globular clusters or sperm-balls, each the product of a single cell. Both ova and spermatozoa may be developed in the same Sponge, though rarely at the same time, so that probably in most cases the ova are fertilised by spermatozoa from another Sponge.

Reproduction in the Sponges is effected by sexual or asexual methods. In the latter, multiplication takes place by the production of internal buds in the shape of groups of cells called *gemmules*, which eventually become detached from the parent Sponge and develop into new individuals. In the sexual process the ovum, after impregnation, usually becomes enclosed by certain neighbouring cells, which form a brood-capsule around it, and in this enclosure, and still within the parent Sponge, passes through the earlier stages of its development. Finally it escapes as a ciliated, somewhat oval-shaped larva, and by means of its cilia swims about and for a short time leads an active existence, but eventually becomes fixed to a base and develops into the sedentary adult stage.

The majority of the Sponges possess a skeleton or supporting framework, composed of material secreted by the Sponge itself, and in some instances supplemented by an admixture of sand, the tests or shells of foraminifera and radiolaria, or the spicules of other Sponges. The skeleton may be composed of calcareous [2] or siliceous [3] spicules, or of an organic substance called *spongin*,[4] which occurs either as a cementing mass which glues the spicules together into a more or less definite system of skeletal fibres, or as an elastic felt-like tissue destitute of spicules, as, for example, in the common Bath Sponge, the skeleton of which is composed entirely of a soft, perforated mass of spongin.

[1] Professor Minchin in Lankester's "Treatise on Zoology."
[2] Calcium carbonate, lime.
[3] Silica, *silex*, flint.
[4] Spongin, a substance allied to silk in its chemical composition.

The beautiful Venus's Flower Basket (*Euplectella*) and the strange-looking Glass Rope (*Hyalonema*) Sponges offer a contrast in structure to the Bath Sponge, their skeletons consisting throughout of siliceous spicules bound together by a siliceous cement. In the Slime Sponges (*Myxospongida*) [1] no skeleton is formed.

The minute spicules of lime or silica vary greatly in shape in different species, forming most beautiful objects for the microscope, and as they are of very great importance in the study and classification of the Sponges, a systematic and highly technical nomenclature of the principal types of form has been established.[2]

The Sponges are grouped under three divisions, each founded on the character and composition of the skeleton. The three classes are: (1) the **Calcarea,** all of which are characterised by a skeleton in which the material is calcareous; (2) the **Hexactinellida,**[3] characterised by the possession of six-rayed or hexactinal spicules; [4] and (3) the **Demospongiæ,**[5] in which the skeleton may be composed of siliceous spicules of various types (never triaxon), or of spongin occurring either alone or in combination with siliceous spicules or foreign bodies, or the skeleton may be altogether absent, as in the Slime Sponges. Although this third division comprises such a vast assemblage of different forms, yet the most divergent are linked together by a complete and gradual series of intermediate forms.

The Sponges included in the class **Calcarea** mostly frequent shallow water, and grow most luxuriantly in shady, sheltered localities. They form a comparatively small group (some 200 recent species), all characterised by a skeleton composed of spicules of carbonate of lime, the spicules being three-rayed, four-rayed, and needle-shaped. Examples of Sponges belonging to this class are the simple vase-shaped Ascon, Leucosolenia, and the Sycon already described.

The **Hexactinellida** include many very beautiful and interesting Sponges, nearly all inhabiting great ocean depths, ranging

[1] *Muxa*, slime.

[2] For a systematic description of the Spicules, *see* Vol. I. Cambridge Nat. Hist.; and Part II. of Lankester's "Treatise on Zoology."

[3] *Hex*, six; *aktis*, ray.

[4] Known as a triaxon type of spicule: *tri*, three; *axon*, axis.

[5] *Demos*, multitude.

from 90 to 3,000 fathoms, and characterised by having the skeleton built up of siliceous spicules, each typically possessing three axes and six rays, or of spicules derived from such a type. To this class belongs the beautiful Venus's Flower Basket (*Euplectella aspergillum*), which forms a most wonderful lattice-like skeleton, shaped like a graceful cornucopia. It is obtained from a depth of some 90 fathoms off Cebu in the Philippine Islands, while another and much larger form (*Euplectella imperialis*) comes from Japan. Another interesting example, the Glass Rope Sponge (*Hyalonema sieboldii*), is obtained by the Japanese deep-sea shark-fishers, by means of hooks attached to their deep-sea lines. The "glass rope," or twisted strand, which is such a striking feature of this Sponge, is really a root-tuft composed of immensely long spicules, which terminate in toothed grapple-like discs, and securely anchor the Sponge in the mud. When these root-strands were first brought to Europe, without the body of the Sponge attached, they were thought to be artificial productions. The body of the Glass Rope Sponge is somewhat like a closed cup in shape, the walls of loose texture and comparatively soft to the touch, and with large and small circular openings, which connect with the interior. The beautiful Lace Sponge (*Semperella schultzii*) also belongs to this class, and has a straight or curved cylindrical and somewhat conical body, the upper surface of which shows a delicate, fine lace-like network, with bands and patches of a coarser pattern.

The class **Demospongiæ** includes all sponges other than the Calcareous and Hexactinellida. Familiar examples are the huge Neptune's Cup Sponge (*Poterion patera*), which comes from the East Indies and is one of the largest of the Sponges; the Sea-Kidney Sponge (*Chondrosia reniformis*); the curious Boring Sponge (*Cliona*), which excavates extensive galleries in oyster shells, so that a shell may often appear to be covered with small round holes; the Horny or Bath Sponges; the Slime Sponges; and the Freshwater Sponges. The Encrusting Sponges are sometimes a great pest on the oyster grounds, as they grow over the shells of the oysters and starve the inhabitants by capturing the food particles floating in the water, which would otherwise reach the unfortunate molluscs. To get over this trouble, in some places the oysters are grown on frames, which from time to time are drawn above the surface of the sea and left exposed during a

downpour of rain. The fresh rain-water kills the Sponges, but the oysters close their shells and so escape injury.

Many of the Encrusting Sponges cover the rocks in deep tidal pools and are very beautiful in their rich colouring of red, yellow, orange, etc. The cup-shaped fine Turkey Sponge (*Spongia officinalis*), the cake-shaped Common Horse or Bath Sponge (*Hippospongia equina*), and the flat, disc-shaped Hard Sponge (*Spongia zimocea*) are the three typical commercial species; the Levant Lappet, which forms great thin flaps like an elephant's ear, is a variety of the Turkey Sponge.

All the commercial Sponges live in sub-tropical and tropical seas, at depths of 2 to 100 fathoms, the world's supply being drawn almost entirely from the eastern half of the Mediterranean, and from the West Indies. They are collected by divers, who descend to the floor of the sea and detach them from the rocks; or are hooked up by means of a kind of long harpoon, or by dredges in the deeper waters. These commercial Sponges are also cultivated from cuttings, the time taken by a small cutting about a cubic inch in size to grow into a marketable Sponge being about seven years.

Sponges appear to be very distasteful to other animals, and to be eaten by very few. Consequently it is not altogether surprising to find an intimate association or symbiosis existing between them and other animals, more particularly crabs. Many of the spider crabs cover themselves with pieces of Sponge, which they attach to their body and legs, where the Sponge grows quite healthily. *Dromia*, the sleeping crab, invariably holds a living Sponge upon its back, certain of its legs having become modified and adapted for the purpose, the Sponge growing and moulding itself to the shape of the body, so that the crab, when at rest, is completely concealed. Another Sponge (*Suberites*) very commonly grows upon the whelk-shell inhabited by a hermit crab, and soon absorbs the shell, so that the hermit crab inhabits a cavity in the Sponge; while within many Sponges minute algæ live in constant partnership.

The Sponges seem to have made their appearance very early in the history of animal life, as one would expect from their comparatively lowly organisation; their fossil remains have been found in the Cambrian strata and in the strata of each succeeding

geological epoch, down to the present day. Chiefly marine and all aquatic in habit, they have a world-wide distribution, the marine forms inhabiting the seas at all depths, from between tide marks to abysmal depths. Sponges are among the lowest of the multicellular forms of life, occupying a more isolated position than any other group of animals, for they are destitute of multicellular relations, though linked by their collared-cells to the colonial Infusorian Protozoa, from which their past history and gradual evolution seem likely to be eventually completely established. But, to quote such a high authority upon the subject as Professor Minchin, " The most conflicting opinions have been, and still are, held upon this point." On account of their isolated position, the Sponges or Porifera are placed in, and are the sole representatives of the Phylum or Sub-Kingdom **Parazoa.**

CHAPTER III

THE CŒLENTERATES OR HYDROIDS: JELLY-FISH, ANEMONES AND CORALS

We have seen that the sponge in its simplest form is a cylinder, closed at one end where it is attached to a base, open at its free end, with its walls perforated by minute openings or pores, and composed of three layers of cell-structure—ectoderm, mesoderm, and endoderm—this last layer consisting of collared flagellate cells. Imagine a transformation to take place in which the minute openings in the wall of the cylinder have disappeared, so that the internal cavity now only communicates with the exterior by a single terminal opening; that the inner layer of tissue or mesoderm has become converted into a very thin structureless layer containing no cells, while the endoderm has lost its collared cells; and that a circle of waving arms or tentacles, formed of the same layers as the body-wall, have grown out round the terminal opening which now serves as the sole aperture for the reception of food as well as for the discharge of effete matters. Such a transformation completed, the resulting organism would serve as an example of the general structure of the group of animals we are now going to consider, while the organism itself would be a typical **Polyp** or **Hydroid.**

The animals grouped together and forming this great division of the animal kingdom are characterised by the possession of a single internal cavity (or *cœlom*), this body-cavity, which is the primitive gut or intestine (*enteron*), only opening to the exterior by a single aperture. It is to signify the possession of this important anatomical feature, absent in all the organisms we have so far examined, that the name **Cœlenterata** [1] was given to this division in which are to be found the Hydra of our ponds, the Sertularian Polyps of the sea, the large Jelly-fish, the graceful

[1] Greek—*koilos*, a hollow; *enteron*, bowel.

Comb-bearing Jellies, the lovely Sea Anemones, Alcyonarians, and wonderful stony Corals. The Cœlenterata are divided into four classes: (1) the **Hydrozoa** (the Sertularians or Sea-firs and the Pond Hydra); (2) the **Scyphozoa** (Jelly-fish); (3) the **Ctenophora** (Comb-bearing Jellies); and (4) the **Anthozoa** (Sea Anemones and Corals).

If on a fine summer afternoon we should visit a pond, the surface of which is partly covered by a green mantle of duck-weed, we should probably have little difficulty in obtaining several specimens of the interesting little Hydra or Fresh-water Polyp. A glass jar should be partly filled with clear pond-water, and some of the duck-weed carefully transferred to it. Then if we closely examine the slender stems of the weed as they hang down in the water, we shall see that attached to some of them are minute green objects about $\frac{1}{8}$ inch in length—specimens of the common Green Hydra (*Hydra viridis*). If now we examine one of these little objects through a pocket magnifying glass, we shall see that it has a very slender cylindrical body, and that the free end is crowned by a circlet of waving feelers or tentacles, from six to ten in number; while the base of the body is slightly expanded, disk-shaped, and acts as a sucker, grasping the stem of the duck-weed for support. On continuing to watch the little Hydra, we shall see that the body slowly elongates and sways from side to side, while the tentacles expand and contract and wave about in all directions.

Along with the Hydra, we have probably captured a number of very minute crustaceans, the so-called "water-fleas," which are now swimming about with their peculiar jerky motion. One of these, in its progress through the water, touches against a waving tentacle of the Hydra and is held fast. The other tentacles bend towards it, and the little creature soon disappears down the mouth of the Hydra. Now, each tentacle of the Hydra is provided with most remarkable stinging cells, called "thread-cells," or *nematocysts*, for the capture of prey. Each of these peculiar cells, which are embedded in the outer skin, or ectoderm, contains a cyst with a very fine hollow thread coiled up inside; while a pointed process projecting from the outer surface of the cell acts as a trigger, so sensitive that at the least touch it causes the coiled stinging thread to be discharged and to sting and

paralyse the microscopic creature that has brushed against the tentacle. These remarkable thread-cells, or nematocysts, are very characteristic organs of the Cœlenterates.

It is quite possible by keeping the jar of water in a cool place near a window to watch the habits of the Hydra at leisure, for the little creature is very hardy, and so long as the weed flourishes, oxygenating the water and keeping it pure, all will be well. It will then be seen that the Hydra does not remain permanently attached to one spot, but that it sometimes goes for a walk, its mode of progress being a series of slow and cautious somersaults. When about to change its quarters the Hydra elongates its body, and, bending over, brings its crown of tentacles into contact with the base to which it is attached. Having fixed itself by its tentacles, the Hydra then detaches the sucker end of its body, and literally, for a second or two, stands upon its head. Then the body is slowly moved over until the sucker is brought into contact with the base, and the whole process is again repeated. Sometimes, however, the Hydra will get as close to the surface of the water as it possibly can, and then, releasing its hold, turn the base of its body upwards and swim along just beneath the surface, head downwards, and by waving movements of its tentacles.

During the summer the Hydra multiplies by a curious budding process. A little roundish swelling makes its appearance on the side of the slender body of the Hydra, and soon becomes furnished at its free end with a crown of tentacles, so that it closely resembles its parent in appearance. A second may form, and the parent stem and buds thus constitute a miniature colony. But the buds do not remain permanently attached; after a little while they drop off, and, developing a detachable base, become free individuals capable of capturing food and fending for themselves. In the autumn ova and sperms are developed by the Hydra, and after fertilisation the eggs, which form little wart-like swellings on the surface of the body, escape into the surrounding water; from them, in due course, another generation develops.

The Hydra has a most remarkable power of reparation of injuries, and the reproduction of individuals out of portions of itself. Thus, if a Hydra should lose two or three tentacles, new ones are quickly grown to replace them; while should the animal itself be cut into several pieces, provided each contains a portion

of the two cell layers, each fragment is capable of developing into a complete animal; so that really the little creature is very appropriately named Hydra, after the monster of the old Greek fable.

In general structure the Hydra is a simple sac, the walls of which are composed of an outer or ectoderm layer one or more cells deep, and an inner or endoderm layer one cell deep, the two layers being separated by a thin, structureless middle lamella or mesoderm. The inner layer or endoderm lines the whole inner cavity of the sac-like body and the interior of the tentacles, and is concerned in the digestion of food, which is taken in at the single opening or mouth in the centre of the circle of tentacles, the insoluble portions being ejected later through the same aperture. Such is fundamentally the structure of all the Hydroida.

We have seen that the Hydra forms buds upon its sides, and that these ultimately drop off. Now, supposing that the Hydra were to grow much larger, form a horny protective covering to its outer surface, produce numerous buds which, instead of separating, elongated and in turn gave rise to other buds, all remaining connected together, each bud crowned with its waving circle of tentacles—a plant-like colony would result. In fact, we should have a typical Hydroid colony, such as may be seen growing in the deep rock-pools, and whose graceful, feathery, horny textured branches are familiar treasures of the seashore, under the name of Zoophytes[1] or Sea-firs.

Such a typical Hydroid colony is formed by the pretty little Obelia, to be found growing in branching filaments upon the submerged wooden piles of piers and breakwaters, and also upon the fronds of the wrack seaweeds. Under the microscope part of a living colony presents a very striking and beautiful appearance, every branch bearing numerous tentacle-crowned polyps, all vitally connected with each other by the common living tissue, which looks like a central pith inside the stem. Both stem and branches are encased by a horny outer cover, and each little polyp is enclosed in a glassy cup-like receptacle or *hydrotheca*. When the polyps are fully expanded, they give to the colony the appearance of some exquisite miniature tree that is covered with tinted, slender-petalled, ray-like flowers.

[1] Greek, *zoon*, animal; *phyton*, plant: the name originally given to these compound Hydrozoa on account of their plant-like habit and appearance.

Less numerous than the flower-like polyps, but dotted here and there about the colony, are long cylindrical bodies (*blastostyles*),[1] each enclosed in a transparent urn or vase-shaped case (*gonotheca*),[2] and bearing numerous roundish offshoots, which vary considerably in shape according to their stage of development, and called "medusa buds." Now, the tentacle-crowned polyps are the feeding or nutritive polyps (nutritive zooids), whose duty it is to obtain and digest food for the general growth and upkeep of the colony; while the less numerous generative polyps (blastostyles) form and carry the medusa buds (generative zooids). These buds, at first, are mere hollow offshoots of the generative polyp (blastostyle), but as they develop they assume the appearance of tiny saucers attached by the middle of their convex surface, the edge of each saucer bearing a fringe of some sixteen short tentacles; while a curious blunt process, like a sort of bell-clapper (called the *manubrium*), and terminating in an opening, or mouth, projects from the centre of the concave surface of each saucer. Ultimately the little saucers become detached from the generative polyp or blastostyle, and, making their escape through an aperture at the top of the transparent gonophore which has served them as a kind of nursery, they swim away as tiny medusæ or jelly-fish.

These tiny medusæ or jelly-fish of Obelia are very beautiful and interesting little creatures. They swim about by rhythmic movements of their saucer or umbrella-shaped bodies, and in their progress through the water the little umbrella may become turned inside out, exposing the manubrium and the four-sided mouth to view. However, this is not a serious accident, and the little jelly-fish soon rights itself, for it has no brittle ribs to crack like those of a real umbrella. Although such a small, transparent, gelatinous creature, the little medusa is quite a complex animal. The margin of the umbrella is furnished with a varying number of tentacles, and in many cases with a series of small sacs enclosing one or more refractive spherules, probably rudimentary sense organs; while at the base of the tentacles there is often a collection of pigment cells in which a crystalline body is embedded, the whole forming a coloured spot or ocellus, which may function as

[1] Greek—*blastos*, a bud; *stylos*, a column: columniform zooids destined to give origin to generative buds.

[2] Greek—*gonos*, offspring: a receptacle for the generative buds.

a primitive eye. The mouth leads into a digestive cavity (*enteron*) which occupies the whole of the interior of the manubrium, and from its base sends off four very fine tubes (radial canals), which, passing at equal distances from each other through the mass of the umbrella to its margin, open into a circular tube or canal which runs parallel with and close to the edge of the umbrella. By means of its fringe of tentacles, which are well armed with thread or stinging cells, the medusa captures its microscopic prey, and the food, swallowed by the mouth, is digested in the manubrium and distributed throughout the entire medusa by the system of canals.

Placed at equal distances on the under surface of the umbrella, and in immediate relation with the radial canals, are four oval bodies, each containing a mass of cells which will develop into ova or sperms, for each medusa bears organs of one sex only, and therefore, according to whether it is a female or a male medusa, will produce only ova or sperms. When these sexual cells are ripe the sperms of the male medusa are shed into the water and carried by the currents to the females, where they fuse with the ova. The fertilised egg develops into a little oval creature called a *planula*, covered with cilia, by means of which it swims about in the sea. After a little time the tiny planula gives up its active, free-swimming life, and, settling down on a piece of submerged timber, rock, or seaweed, fixes itself by one end and becomes converted into a little polyp with a waving circle of tentacles. It captures food, grows, sends out lateral buds, and soon becomes converted into a complex, branching Obelia colony, the polyp members of which are destitute of fully developed sex cells.

In Obelia we have an instance of what is termed *an alternation of generations*—a branching colony of polyps, certain of which produce asexually formed medusæ, which in turn become detached, develop male and female organs, and produce sexually a ciliated offspring, which becomes the founder of a colony of sexless polyps multiplying by a process of budding. This interesting phenomenon is very common among the Hydrozoa, being particularly marked in cases like Obelia and allied species, where the asexually formed generative polyp or medusa becomes detached and swims away. But these free-swimming generative medusæ do not occur

in all the Hydroids; in many species they remain attached to the colony, looking like little umbrellas fastened by their ferrules to the colony, and produce their eggs and ciliated planulas in that situation. These permanently attached generative buds generally lose to a greater or less extent the umbrella-like form characteristic of the free-swimming medusæ. On almost any shore, specimens of the dead and dried polyparies of various Hydroids, such as the "Squirrel's-tail," the "Sea-cypress," the "Bottle-brush," the "Sea-fir," and the "Sea-beard" or "Lobster's-horn," to quote the popular names expressive of their general appearance, are to be found.

The graceful, branching forms of the colonies, varying in the most wonderful degree in different species, the delicate, varied tints of the tentacle-crowned polyps, and their extraordinary life-history, make the Hydroida most deeply interesting forms of life. To quote Professor Hincks, who devoted many years of his life to the closest study of these remarkable organisms, "there must always be a certain fascination in a history which tells us of animals composed of multitudes of individuals living an associated life, and so combining as to produce the most graceful plant-like structures—vegetating like a tree—putting forth thousands of polyps, like leaves, each a provider for the commonwealth—putting forth also a company of buds, charged with the perpetuation of the species, ripening in transparent urns and scattering their winged seeds broadcast, or sent forth, moulded and painted by the highest art, like fairy emigrant ships freighted with young life, to colonise distant seas. And these are the simple facts of Nature."[1]

The **Hydrocorallina** resemble the Reef Corals in forming a calcareous skeleton, and indeed were at one time supposed to belong to the same class. Thanks, however, to the researches of Professor L. Agassiz, Professor H. N. Moseley, and Professor Hickson, their true character and life-history has been worked out and proves them to belong to the Hydroids. The Hydrocorallines are divided into two families, called respectively *Millipores* and *Stylasters*. The Millipores form massive laminate or branched growths of a strong coral-like character, dotted over with minute pores, and having within a tubular structure crossed

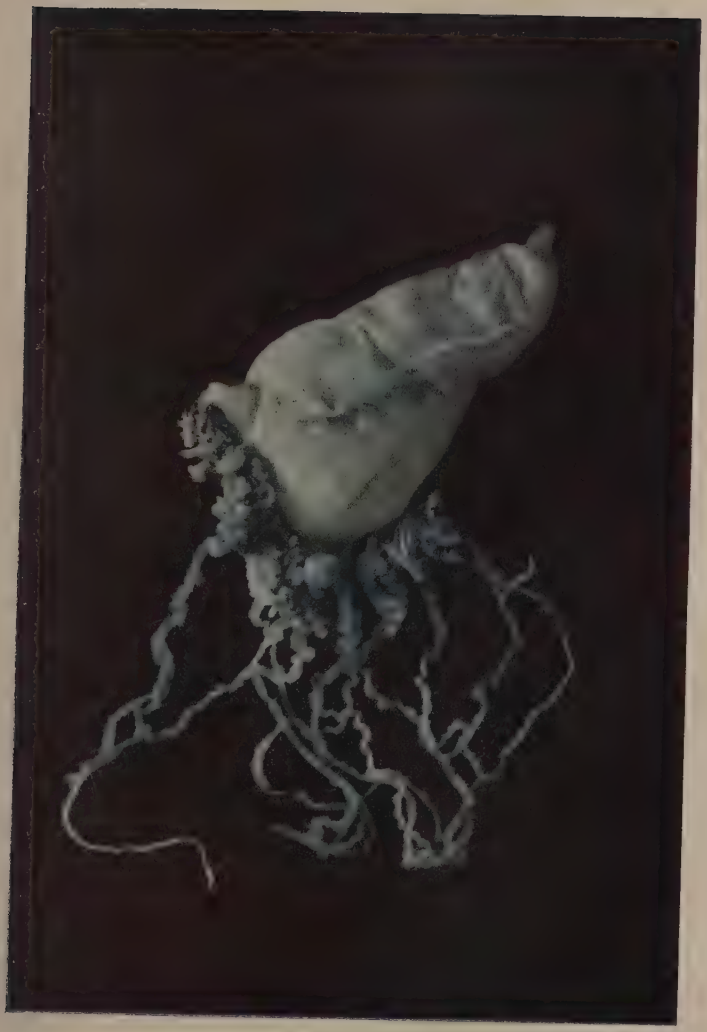
[1] "Quarterly Journal of Science," Vol. II., No. 7, p. 416.

by platforms or tabulæ. They are reef-builders, and contribute to the solidity of the coral reef structure. Free-swimming minute sexual medusæ are produced, which swim away from the parent colony, and having deposited their eggs, shrivel up and die. The second family, the Stylasters, are remarkable for the elegance and beauty of their branching fan-shaped forms, and exquisite colouring. Their branches are covered with numerous groups of pores, each pore having a calcareous spiny projection or style. Numerous blister-like swellings or ampullæ on the surface of the colony contain the generative buds, which, however, never become free medusæ.

The **Siphonophora**[1] are free-swimming Hydrozoa, each consisting of a colony or assemblage of individuals united in a common stock (called a *hydrosoma*), and placed under a more or less tough, bladder-like bag, which acts as a float. To this order belongs the well-known "Portuguese Man-of-war" (*Physalia*), whose air-sac is in the form of a somewhat pear-shaped bladder, pointed at one end and rounded at the other, crowned by a long, low crest which acts as a sail. Very often in the tropics a regular fleet of these Portuguese Men-of-war are to be seen sailing along upon the surface of the sea, their coloured floats all well above the water, so that the crest acts as a miniature sail; while from beneath the float hang an assemblage of polyps, medusa-buds, and long trailing tentacles, sometimes many feet in length, and armed with batteries of stinging cells sufficiently powerful to produce very painful results; indeed, the natives inhabiting the island of Funafuti are said to have a very great fear of being stung by them. Drifting along on the surface of the sea, these Physalia present a very pretty appearance, and always excite admiration and interest. Sometimes during the summer months they are to be seen off the south-west and west coasts of England.

Another very beautiful form is called the "By-the-wind Sailor" (*Velella*), which looks like a dainty circular raft, with an obliquely placed semicircular-shaped sail; and is just the graceful little craft one might imagine the sea-fairies of old voyaged in. All round the edge of the dainty disk-shaped raft depend a fringe of gaily coloured tentacles, which may be purple, bright blue, or brown in colour.

[1] Tube, or siphon-bearers.



PORTUGUESE MAN-OF-WAR (*PHYSALIA*)

The **Scyphozoa** include the larger and commoner kinds of Jelly-fish, hundreds of which may be seen during the summer months swimming along by gracefully expanding and contracting their umbrella-shaped disks, or drifting quietly along the tidal currents. At night many of them present a very beautiful appearance, becoming lit up by a soft yet brilliant phosphorescence, veritable living lamps, glowing with many-coloured lights as they rise from out the dark, mysterious depths.

One of the commonest of these large Jelly-fish, often cast up in large numbers on the shore, is the Aurelia,[1] easily recognised by its saucer-shaped umbrella measuring 3 or 4 inches in diameter with four red or purple horseshoe-shaped bodies (the reproductive masses) embedded in the jelly near the centre of the body. The margin of the umbrella is fringed by very short, fine tentacles, and indented at regular intervals by a series of eight notches, each containing a little cyst, which is regarded as a primitive eye-spot and is covered by a pair of minute flaps. Hence these larger Jelly-fish have been called "Covered-eyed Medusæ," to distinguish them from the Hydroid type, which are without these flaps, and were called "Naked-eyed Medusæ." The mouth is in the centre of the under surface of the body, and is surrounded by four long and delicate processes called the oral arms. The fertilised egg of Aurelia develops into a hollow oval embryo, covered with cilia by means of which it moves through the water. It soon settles down, however, and becomes attached at one end to some base on the floor of the sea, where it changes into a small polyp with a mouth, stomach, and sixteen tentacles; it was formerly thought at this stage to be a distinct individual, and received as such the name of *Hydra tuba*, or the "Trumpet Polyp." After feeding for a while, the little polyp begins to show a series of transverse constrictions or waists, which become smaller and smaller until the little creature looks like a pile of saucers with deeply indented edges. In due course the little saucers detach themselves and swim away, their transformation being completed by the filling in of the spaces between the eight deep indentations of the margin of the saucer, and the development of the fringe of fine tentacles, when the little creatures are recognised as small Aurelias.

[1] *Aurelia aurita*.

Most of the Scyphozoa resemble Aurelia in the general features of their structure, but vary considerably in certain points. Thus the umbrella, instead of being saucer-shaped, may be cup-shaped, or conical; though many pass through an alternation of generations such as I have briefly described in Aurelia, others do not, the ciliated larvæ developing directly into Jelly-fishes like the parents without passing through a fixed polyp stage. Lucernaria (*Haliclystus octoradiatus*), a small and interesting form, differs widely from the rest in attaching itself by a short stalk developed from the centre of the outside of the umbrella to seaweeds and rocks, and can creep about or swim at pleasure.

The Comb-bearing Jellies (*Ctenophora*) have no disk or umbrella, and do not resemble the true Jelly-fish or medusæ, either in shape or movement. Generally globular or cylindrical, rarely ribbon-shaped, they form a group of active, free-swimming, gelatinous, transparent animals, at times appearing in vast numbers in the surface waters of the sea. The beautiful, crystal-bright, so-called "Sea-gooseberry" (*Hormiphora plumosa*) is a familiar Comb-bearer, frequently to be seen in large numbers during the late spring and early summer months, swimming close in to shore, hundreds often being left stranded by the receding tide. It has a wonderfully bright, transparent, globular body, provided with eight rows of swimming-plates or combs; each plate consisting of a comb-like band of quite large cilia, the rapid movements of which present a most interesting sight. As the Hormiphora swims about in the collecting-jar, we shall see that two long, feathery tentacles are protruded from each side of the body, and wave about in the water, only to be as suddenly retracted within their sheaths. They are destitute of thread-cells or nematocysts, which are replaced by a number of adhesive cells, carrying out the same function as organs for the capture of prey. At one end of the body is a single opening, the mouth, which communicates with a gullet and stomach; from the latter canals pass beneath the swimming-plates or combs, and two canals pass from the base of the stomach to the opposite end of the body, where they open as two minute excretory-pores. Centrally placed between these pores is a remarkable structure which functions as the nerve centre as well as an "audatory" or balancing sense organ. There is no budding, colony formation, or alternation of generations among

Hydra Fusca, with young bud

A hydroid Medusa

Beroë ovatus

Sea Anemones

the Comb-bearers; they are all produced from eggs, and the movements of the young can be seen long before they escape from the egg.

Other interesting examples of the Ctenophoræ are the handsome Venus's Girdle (*Cestus Veneris*), a long, slender, ribbon-shaped form, which may attain a length of several feet, and is a delicate blue colour; and the little rosy tinted, cylindrical bodied, wide mouthed Beroë.

The **Anthozoa** [1] include the Sea Anemones, Corals, Sea-fans and Sea-pens, and those curious, fleshy-looking masses sometimes seen thrown up on the shore, and popularly called "Dead Men's Fingers." The Anthozoa are divided into two orders, the *Zoantharia*, with the tentacles and mesenteries in sixes, to which the Sea Anemones and the majority of the Corals belong; and the *Alcyonaria* (with eight mesenteries and eight tentacles), to which belong the beautiful Red Coral, the Organ-pipe Coral, the Sea-fans and Sea-pens. All are more or less familiar, beautiful objects, well deserving from their external appearance the name of flower-animals or Anthozoa. They are dwellers in the sea, or in a few cases in brackish water, and are usually brilliant in colour, many of the Sea Anemones when fully expanded looking like gloriously tinted daisies and dahlias.

The individuals are formed on the same general lines as the polyps of the Hydrozoa, but with certain important differences, chiefly as regards internal structure. Thus the mouth does not communicate at once with a sac-like stomach, but first leads into a short tube or gullet, which is connected below with the walls of the main digestive cavity or stomach by a radially arranged series of fleshy projections or partitions, called the *mesenteries*, in which the sexual cells (sperms and ova) are developed. The chambers between the partitions communicate with each other and with the hollow tentacles. Below the gullet the free edges of the mesenteries are thickened to form digestive organs known as *mesenteric filaments*. When the sexual cells are ripe, they are discharged into the stomach cavity, and then pass by way of the mouth into the surrounding water.

It will be seen, therefore, that the Anthozoa differ from the

[1] Anthozoa—Greek, *anthos*, a flower, and *zoon*, an animal. The term Actinozoa is also applied to this division of the Cœlenterates, and is derived from the Greek, *aktis*, a ray, and *zoon*, an animal.

other Cœlenterates in the possession of a gullet or stomodæum, mesenteries, and mesenteric filaments. They begin life, on their escape from the parent, as ciliated free-swimming larvæ, but in the course of a few hours or days, as the case may be, settle upon some object on the floor of the sea, and at once (if of colonial character) commence the process of budding, which gives rise to the colonies of the adult stage. Nearly all are fixed or sedentary in their habits, though many of the Sea Anemones travel considerable distances by gliding over the rocks or seaweeds upon which they rest. That some of the Sea Anemones are comparatively long-lived creatures appears evident from the record of one which was taken from the Firth of Forth by Sir John Dalyell in 1828, and which flourished in captivity until August 4th, 1887, when it died.

The majority of the Anthozoa are dwellers in comparatively shallow seas, though a few have been dredged up from great depths, and they extend from the shores of the Arctic and Antarctic to the warm seas of the Equator.

The Sea Anemones are such familiar objects of the tidal pools on rocky coasts that they need no special mention here. Attention may, however, be drawn, in passing, to one or two points of interest concerning them. Abundant round the coasts of England, they are almost cosmopolitan in their distribution, attaining their greatest size in the warmer tropic and sub-tropic seas. They are most voracious creatures, killing or paralysing their prey by means of their numerous thread-cells (*nematocysts*), often becoming greatly and, one would imagine, uncomfortably distended, from the size of the object they have swallowed. They have remarkable powers of replacing lost parts, should some of the tentacles or part of the body be injured or altogether removed. Some are of very great interest, as affording striking examples of that mutual association of different organisms which is termed "Commensalism." Thus there are some Anemones which are always to be found living on a whelk-shell that is inhabited by a hermit crab—the two totally dissimilar animals associating together in the most friendly manner. The Anemone, by taking up this position, secures the advantage of transportation from place to place during the hermit crab's wanderings in search of food, and also gains a share of the captured booty; while the crab gains when at rest, in being partly screened from view by the

fully expanded Anemone, whose numerous tentacles, plentifully supplied with thread-cells, also probably serve to keep many unwelcome visitors away, and also may at times help in the killing or paralysing of prey.

An even more intimate association is exhibited in some species which invariably contain numerous "yellow cells," which have been shown to be really minute one-celled plants thriving in mutual partnership or symbiosis with the animal cells of the Anemone. While the carbonic acid gas given off by the animal cells is useful to, and absorbed by, the minute plants, the liberated oxygen given off and the starch formed by these vegetable cells are of great value to the Anemone. In some of the Anemones both ova and sperms are developed within the same animal, while in other genera the sexes are distinct. The ova undergo their early stages within the parent, and a ciliated planula is set free.

The Stony Corals, or **Madreporaria**, belong, like the Anemones, to the order Zoantharia; and, as may be seen from the photograph of an expanded specimen of the little Devonshire Coral (*Caryophyllia Smithii*) facing p. 53, a living simple, solitary Coral somewhat resembles in outward appearance an Anemone. On top of the body there are a series of tentacles, and a central disk within the circle of tentacles, in the midst of which is a small mouth. A coloured tissue, like that of the outside of the tentacles and disk, covers the outside of the body, and the disk is marked with lines which appear to radiate from the mouth, and if touched will contract slightly so that a hard structure is felt beneath it, made up of a number of thin, vertically placed plates, with their edges upwards. Between these plates, or *septa*, as they are called, spaces exist (the interseptal spaces) in which there is a process of the under part of the disk, the mesenteric folds. If the disk be removed, the tops of the numerous septa will be seen covered with a filmy structure, and between each pair of plates a soft mesenteric fold. Just under the opening of the mouth, and in the middle of the top of the Coral, there may be a hard projection called the *columella;* or, should this not exist, the stomach cavity occupies its place. Where a columella is present the stomach is immediately above it, but in either case the stomach has the mesenteries radiating on all

sides. The tentacles are hollow, and open into the interseptal spaces, so that the fluid of the stomach can pass around and up into all the soft internal parts. The mouth is extensible, has muscular sides, and passes at once by a narrow space to the digestive cavity below. Nematocysts (thread-cells) and cilia are present in these parts as well as on the tentacles.

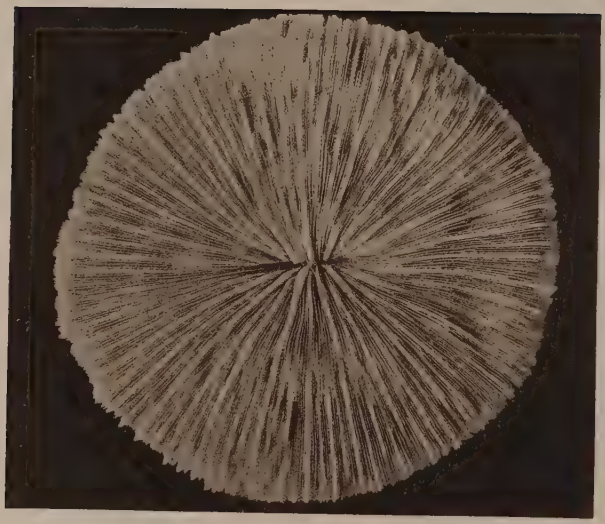
Minute organisms floating in the water come in contact with the top of the Coral, and are stopped by a mucus secretion or by the nematocysts, and moved towards the mouth by the tentacles, or by the motion of the cilia. The prey so captured disappears inside the mouth to be digested, and the juices are circulated from cell to cell, adding to the bulk of the polyp. The calcareous parts of the prey, supposing it possessed a shell, and a certain amount of the salts of lime held in solution by the seawater, are retained in the structures of the mesoderm of the body, and out of this material the hard part of the Coral is formed, the carbonate of lime being deposited in long or short, slender needles, or prisms, in the interstices of a peculiar connective tissue of the mesoderm.

A piece of Coral, when cut into thin slices or sections for examination under the microscope, shows numerous radiating lines once occupied by organic matter, and starting from them on all sides are masses of the prisms and needles of carbonate of lime. This texture varies in different Corals, in some being very dense, in others very lax and porous; while in the latter type the texture of the hard part is very spicular, the ends being joined to form a kind of cellular structure. It is upon these two distinctive types of structure that the two great divisions of the Madreporaria —the **Aporosa** and the **Porosa**—are based.

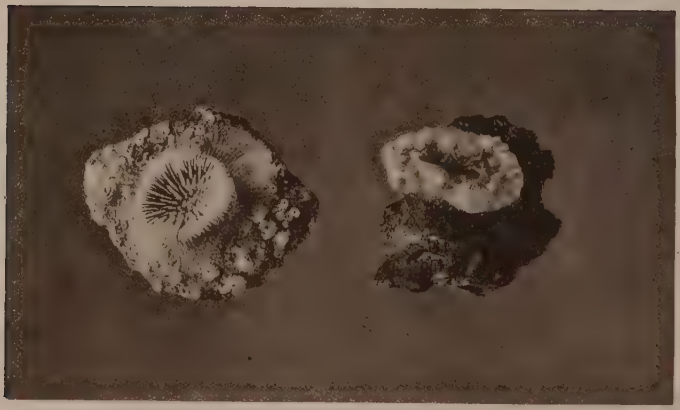
The hard parts of the Coral are wonderfully regular in their radiation and numerical structure. The theca, or wall, which forms the cup of the Coral, is closed below at the base and open at the opposite end, the calice. The thin vertical plates, or septa, pass from the inside of the cup towards the central axis, and are free above at the calice, and sometimes not joined to anything in the centre of the cup. But there may be a columella in the centre, which starts from the bottom of the cup and grows upwards; or it may be formed by the ends of the septa. In some Corals the interseptal spaces are open from top to bottom, while in

Polyps of *Pennatula phosphoria*, the Sea-pen

Polyps of *Corallium rubrum*, the Red Coral



A Mushroom Coral



Caryophyllia smithii, the so-called " Devonshire " Coral; dead and expanded specimens

others thin pieces of carbonate of lime cross them, more or less, cutting off the lower parts from the upper. These *dissepiments*, as they are called, are secreted by the animal, which lives above the upper one. Outside the cup are a series of longitudinal ridges, or ribs, in relation to the septa within, and they may be united by cross-bars.

While some Corals remain as solitary and separate individuals throughout their life, others, and particularly the reef-builders, become compound; that is to say, they propagate or increase by a process of budding from the parent, and then these first buds in turn give rise to a succession of buds. First a little projection appears on the side of the parent cup, and soon a few tentacles are formed, until by its outward and upward growth the little bud resembles the parent. Other buds now arise, and all grow upwards in a bush-like form, fresh successions of buds constantly being produced. As the growth progresses, either the bush shape remains, or else structures composed of layers of hard tissue arranged in cellular compartments or cross-bars, so as to give both lightness and strength, are grown between the buds and parent, connecting the whole into a solid mass, or *exotheca*. Thus an individual Coral perfect in itself, like the little Devonshire Coral and the Mushroom Coral, is called a *Corallum;* while a member or an individual which has budded or divided off, and yet still remains as part of a whole, is called a *Corallite*.

Ova are produced by all the Corals, and escaping from the mouth of the parent become long, ciliated planulæ, which soon fix themselves to a base and become like the parent in appearance. The growth of the individual is accompanied by an increase in the number of mesenteries within the body, and of solid septa between each pair of mesenteries.

The little Corals to be found on the southern coasts of England are simple, and do not form reefs, for the temperature of the sea around our coasts to-day is not sufficiently high to support the life of the reef-building Corals, although there is abundant evidence from the fossil remains of reef-building Corals preserved in various strata to show that in the geological past our shores were lapped by the waves of a tropical sea. The reef-building Corals can only flourish in a warm sea—where the temperature is never lower than 68° F., and may rise to 86°. Moreover, the sea-water must

be highly aerated, pure, free from sediments, and contain an abundance of living organisms: conditions that can only exist in the neighbourhood of islands standing in deep water. Nor are the reef-building Corals ever to be found at such great depths as those at which some of the simple solitary Corals live, for the temperature of the sea rapidly diminishes with depth, so that the 86° to 68° F. necessary for the growth of the reef-builders is not maintained beyond a depth of about 20 fathoms. Therefore, to see the wonderful reef-building Corals of to-day, we must visit the warmer waters of the Indian, Pacific, and Atlantic Oceans and the Caribbean Sea.

Coral reefs are divided into three types: shore-reefs, which fringe the shores of continents or islands; encircling or barrier reefs, which rise from deep water at a greater distance than the shore-reefs from land, encircling an island, or stretching like a barrier along the coast, like the wonderful reef which fronts the north-east coast of Australia, with a length of nearly a thousand miles, running parallel with the shore at a distance varying between twenty and seventy miles; and atolls, or lagoon islands, which are low reefs generally but a few hundred yards wide, enclosing a lagoon. An atoll, or lagoon island, presents a most wonderful sight, one that remains vividly impressed upon the memory of the traveller for the rest of his life. As the ship approaches the atoll, the voyager sees rising out of the deep blue sea a low more or less circular belt of land dotted with feathery crowned coco-nut trees. A white line of breakers fringes the reef, thundering against it and sending up great spouts of spray and foam, while within the encircling ring of Coral reef the quiet waters of the lagoon shine like a burnished mirror.

As one gazes at the mighty onslaught of the waves dashing perpetually with cataract force against the low reef, one feels that even the hardest rock must ultimately yield to such terrific battering. "Yet," to quote Dr. Hartwig, "the insignificant Coral islets stand and are victorious; for here another power, antagonistic to the former, takes part in the contest. The organic forces separate the atoms of carbonate of lime one by one from the foaming breakers, and unite them in symmetrical structure. Let the hurricane tear up its thousand huge fragments, yet what will this tell against the accumulated labours of myriads of archi-

tects at work night and day, month after month? Thus do we see the soft and gelatinous body of a polyp, through the agency of vital laws, conquering the great mechanical power of the waves of an ocean, which neither the art of man nor the inanimate works of Nature could successfully resist."

Fascinating as the subject is, it would be quite impossible in the space at my command to enter into a full discussion of the formation of these Coral reefs and islands. Therefore I must refer my readers to the pages of Charles Darwin's deeply interesting and clearly written "Coral Reefs," which is still considered by palæontologists and geologists as the most authoritative statement on the subject.

Darwin's assumption as to the substratum of these islands being composed of the calcareous remains of invertebrate marine animals, and his theory of gradual land subsidence as the primary cause of Coral-reef formation, have been fully confirmed by the recent experimental borings carried to a depth of 1,114 feet on the island of Funafuti. That his theory of gradual subsidence may not be applicable in a few cases is quite possible; other natural causes, such as the abundant deposition of the remains of calcareous organisms, may have been under favourable conditions sufficient to raise the summits of submerged mountains to a level where the reef-forming Corals can commence to flourish. But these isolated cases all require far more careful and systematic investigation than they have yet received, and though under certain favourable conditions atolls and reefs may thus be formed without the subsidence of land, their presence in no way upsets Darwin's theory as applied to the innumerable examples of the various reef formations which stud the Indian, Atlantic, and Pacific Oceans.

The numerous members of the **Alcyonaria** are characterised by having eight tentacles, or the tentacles in multiples of four—not simple like those of the Zoantharia, but each consisting of a main stem with two rows of lateral branchlets. These pinnate [1] tentacles form a single row, or circle; are enlarged at their base, and each communicates with one of the eight mesenteric spaces. To this order belong the so-called Blue Coral (*Heliopora cærulea*), the Sea-pens (*Pennatulidæ*), the Sea-fans, Red Coral, and Organ-pipe Coral.

[1] Pinnate—branched.

The Sea-pens are free-swimming, more or less pen-shaped Alcyonarians, with a wide geographical range, and living at various depths of the ocean, some being quite shallow-water forms, others living at a depth of some three hundred fathoms.[1] Many are highly phosphorescent, and they are often brilliant in colour. Some live with their slender pointed root in the sand, but they are not fixed to any base. Their surface is soft, and may have three kinds of polyps upon it. The central stem is composed of horny and calcareous matter, traversed by bands of soft tissue, the ectoderm usually containing calcareous spicules, often very beautiful in colour and form.

The handsome Red Coral (*Corallium rubrum*), the hard cleaned stem of which is familiar as an ornament, is an Alcyonarian which lives attached to rocks and other substances on the floor of the sea in the Mediterranean, and in parts of the Atlantic and Pacific Oceans. Off the coast of Algeria, the east coast of Spain, and the coasts of Italy and Sicily there is an important Coral fishery, in which some six hundred or more small boats, fitted with a rude dredging apparatus for breaking off and bringing up the Coral, are employed.

If a portion of the red stem of the Coral be examined, delicate striations will be noticed upon it, and a section will show a concentric arrangement of calcareous material tinted with delicate shades of red. The polyps form this stem by the deposition of the calcareous grains in a connective tissue, the whole being covered with a somewhat dense soft part, in which there are canals or water systems running over the hard stem. The polyps are large and handsome, crowned by eight feathery tentacles, and having a thick base. A mass of spicules surrounds the hard stem, and becomes gradually connected to form the outer layer. The colony increases by budding or gemmation, a process which leads to an increase in the number of polyps forming a colony, but not, so far as observed, to an increase in the number of colonies. Sperms and ova are formed in separate individual polyps, sexual reproduction occurring usually about once a year. The ova are probably fertilised after their discharge from the parent's mouth, and become ciliated. The free-swimming larva, or *planula*, as

[1] During the *Challenger* Expedition, specimens were dredged up from 1,200 to 2,125 fathoms.

it is called, after a short period settles down and becomes permanently attached to some substance on the floor of the sea. Developmental changes then take place, leading to the formation of a mouth, stomach, and perigastric cavity; while the calcareous matter gradually deposited by the connective tissue, and forming the stem and spicules, is derived from the products of digestion, for it is from the shells of the minute animals which constitute the food of the polyp that the carbonate of lime for the building up of the Coral stem is chiefly, if not entirely, obtained.

The Sea-fans have flexible stems enclosed in a soft outer layer, in which the polyps may be embedded or may project as little wart-like growths. Spicules of carbonate of lime are present in the soft parts. The stem is formed of concentric layers of material, which are deposited in the tissues of the deepest portion of the soft parts, one over the other, the outer surface being marked with grooves. They have a wide distribution, and are very beautiful objects both in colour and form.

The handsome, deep purplish-red Organ-pipe Coral (*Tubipora musica*) is an Alcyonarian which forms very considerable masses, composed of a multitude of small cylindrical tubes placed in rows one over the other, and separated by a kind of semi-tubular and cellular tissue; it is found in the Red Sea and Pacific Ocean. A living specimen presents a very beautiful appearance, with the little polyps fully expanded, showing their graceful, feathery tentacles. If alarmed, the tentacles instantly close, and the polyp withdraws within the tube. Inside the more or less cylindrical tubes there are funnel-shaped projections, and also incomplete horizontal tabulæ, but no septa.

The commonest British Alcyonarian is the so-called "Dead Men's Fingers" (*Alcyonium digitatum*), which may be found in rock pools exposed at low spring tides, or dredged up from depths of 40 to 50 fathoms. Out of the water it presents an uninviting appearance of a sickly whitish-yellow or pink colour, an ugly mass of slimy-looking substance, shaped like a distorted hand. When the mass is returned to a vessel filled with clear sea-water a transformation soon takes place, the surface of the mass becoming covered with large and beautiful polyps.

The fossil remains of Cœlenterates are very numerous and

interesting; they first appear in the Cambrian strata, and are present in all subsequent formations. The earliest Hydrozoa, the fossil Graptolites (Greek, *graptos*, written) are found in Cambrian, Ordovician, and Silurian strata, as slender colonies shaped like a quill pen. A great group of Corals, the **Rugosa,** which flourished as reef-builders in the Palæozoic age, have their modern representatives in the small Guynia and Duncania of the floors of the Mediterranean and the Atlantic Oceans. The Aporosa and Perforata, faintly foreshadowed in Palæozoic ages, increased in importance in early Secondary times; and the **Tubipora,** to which the Organ-pipe Coral belongs, are probably of great antiquity, for there are forms like them to be found in the Devonian rocks. The Oolitic age had its great reef-building Corals, and the chalk contains beautifully preserved remains of a fauna which closely resembled that of the deep seas of the present day, while many genera of Tertiary Corals still exist.

CHAPTER IV

THE ECHINODERMA: STARFISHES, SEA URCHINS, AND HOLOTHURIANS

ALL the creatures included in the great division of the Animal Kingdom described in this chapter are inhabitants of the sea,[1] and owe their name of the **Echinoderma**[2] to the prickly nature of their skin, which is more or less beset with spines, granules, or plates of carbonate of lime. The division includes the Starfishes, Sand and Brittle Stars, Feather Stars, Sea Urchins, and Sea Cucumbers or Holothurians: all creatures characterised by a prevailing radial symmetry of both their external and internal structure; while the presence of a gut distinct from the body-cavity (*cœlom*) shows an advanced superiority of organisation sufficient to separate them clearly from the Cœlenterates, with which they were associated by the early zoologists.

The Echinoderma are a most deeply interesting group of animals, not only on account of their great antiquity and beauty of structure—they range in time from the Cambrian through all succeeding geological formations—but also because of the wonderful series of changes or transformations through which they pass before reaching the adult stage; changes of form so profound that no one who had not followed the transformation step by step would, on being shown a larva and adult, recognise them as being the same animal at different stages of its life. The sexes are distinct in most of the Echinoderma, and the fertilised ova hatch as uniformly ciliated free-swimming embryos, which gradually develop a digestive tube with two openings. The cilia become restricted to one or more transverse ridges, and the larva passes from a more or less spherical condition into one exhibiting a very complete bilateral symmetry, and thence by a series

[1] A Holothurian (*Synapta similis*) is said by Ludwig to enter the brackish waters of the tropical mangrove swamps.

[2] Greek, *echinos*, hedgehog; *derma*, skin.

of remarkable changes develops into the radially symmetric adult.

The most characteristic feature of the internal anatomy of the Echinoderma is the presence of a series of organs which together form what is called the "water-vascular system" (*hydrocœl*). This is a special division of the body-cavity or cœlom, in the form of a ring-shaped canal surrounding the mouth, and giving off long, radial canals, usually five in number, which run to the outer parts of the body. Each of these radial canals carries a double series of lateral branches, which push out the skin so as to appear as appendages of the body and are the tube-feet by means of which the animal moves along the floor of the sea; they also function as sensory and respiratory organs. From the ring-canal in the space between two of the radial canals a vertical one, called the stone-canal, is given off, which communicates with the exterior by means of a porous plate pierced by fine canals, which from a fancied resemblance of its outer surface, covered with wavy lines, to a coral, is called the *madreporite* or *madreporic body*. Powerful cilia, capable of producing a strong inward current, line these canals and the stone-canal, so that the whole water-vascular system is kept tensely filled with sea-water.

The Echinoderma are divided into two great sub-phyla or subdivisions: (1) the **Pelmatozoa,**[1] or Echinoderms provided with a stalk by which the animal is attached to a base, either throughout its life, or in the larvæ stages only; and (2) the **Echinozoa,**[2] or Echinoderms without stalks at any time of their life. To the first belong the beautiful living Feather Stars (*Crinoidea*), and the extinct forms *Blastoidea* and *Cystoidea;* while to the latter belong the Common Starfish, the Brittle and Sand Stars, the Sea Urchins, and the Holothurians.

We may take as our first example of the Echinoderms, and of the first class, the **Asteroidea,**[3] of the Echinozoa, the common reddish-coloured Five-fingered Starfish (*Asterias rubens*), to be

[1] Greek, *pelma*, a stalk; *zoon*, animal.

[2] Greek, *echinos*, hedgehog; *zoon*, animal. I have retained the name Echinozoa for this sub-phyla, as it is still used in the British Museum (Natural History) Guide to designate it, and as it is more familiar and descriptive than the term Eleutherozoa, now adopted by many authors.

[3] Greek, *aster*, a star; *eidos*, form.

found near low-tide mark on most shores. The animal has a star-shaped body, consisting of a central part called the central or body disk, and five symmetrically arranged arms or rays, broad at their base, tapering slightly towards their bluntly pointed tips, the whole animal presenting somewhat the appearance of a conventional drawing of a star. Examining it more closely, we shall see that the Starfish has an upper or dorsal, and an under or ventral surface (also called the *aboral* and *oral surfaces*), the upper surface being convex and of deeper colour, the under surface flat and of lighter tint.

Turning the Starfish over on its back, we see in the centre of the oral surface a five-rayed aperture which communicates directly with the mouth, and from which radiate five narrow grooves, each traversing the centre of the oral surface of one of the rays throughout its entire length. These are the *ambulacral grooves*,[1] and bordering each there are two or three rows of movable spines, called the *ambulacral spines*. Filling each ambulacral groove can be seen the numerous tube-feet, soft tubular bodies capable of being greatly extended, and terminating in sucker-like ends. It is by means of these tube-feet that the Starfish creeps along the floor of the sea, and is also able to right itself if turned over on to its back. A small bright red spot, the eye, can be seen at the extremity of each of the ambulacral grooves, and immediately over it is a median process called the *tentacle*, similar in appearance to the tube-feet, but smaller, destitute of a terminal sucker, and really functioning as an olfactory organ. These tentacles are much more important organs than the eyes, for the Starfish is guided to its food far more by their means than by the sense of vision.

The internal skeleton of each ray consists of two longitudinal series of plate-like joints, called the *ambulacral ossicles*, which lean against each other in the middle line above, and so form the sides and roof of the ambulacral groove. The external skeleton is a network of rod-like plates embedded in the tough leathery skin, while from the soft interspaces between the network project innumerable minute transparent membranous pouches, which are respiratory in function.

Scattered about over both the upper and under surfaces of

[1] Latin, *ambulacrum*, a place for walking.

the Starfish are a number of very remarkable bodies, microscopic in size, which, when examined with a strong magnifying glass, are seen to have the form of minute pincers, each consisting of two movable blades crossing each other below and articulated to a basal piece. The function of these curious organs, which are called *pedicellariæ*, is to keep the Starfish clean by seizing hold of any particles or small organisms which might attempt to settle on the skin. When touched, these tiny blades open and then snap together smartly.

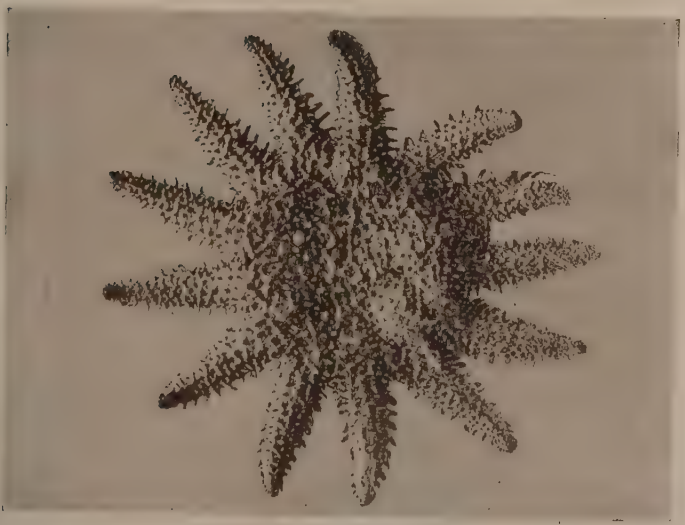
On the upper surface of the body, and situated in a space between two of the rays, may be seen a small, round plate, the surface of which is covered with fine grooves. This is the madreporite, through which water is constantly being drawn by the action of cilia into the water-vascular system. Near the centre of the upper surface may also be made out the minute opening of the anus, for the discharge of effete matters.

The mouth of the Starfish opens through a short passage (the œsophagus) into a wide, five-lobed sac or stomach, the walls of which are greatly folded; each of the lobes is opposite one of the rays, and the whole sac is capable of being everted through the mouth, folded over any object desired as food, and then by means of special retractor muscles withdrawn once more into the interior of the body. Dorsally, this remarkable sac-like stomach communicates with a small chamber, which in turn opens into a very short, conical intestine leading directly upwards to open at the surface by the anus.

The Starfish is one of the great pests of the oyster fishery, and is responsible for a very great financial loss annually, owing to its depredations on the oyster beds, for it is very partial to a meal of the best native oysters. According to Schiemenze,[1] who has carried out a number of experiments, a bivalve may be capable of resisting a sudden pull upon its shells of 4,000 grammes, but sooner or later has to yield to a steady, prolonged pull of 900 grammes, while a Starfish can exert a steady pull of some 1,350 grammes. Now, the Starfish seizes the oyster, and folding itself umbrella fashion over its prey, so that the edges of the valves of the oyster are brought near the mouth, the tube-feet of the middle

[1] *Mitth. des deutschen Seefischervereins*, xii., 1896, and Journal Marine Biological Association, iv., 1895–97, p. 266.

Astropecten irregularis



A " Sun " Starfish

Palmipes membranaceus, the so-called " Bird's Foot " Starfish

Ophiopluteus larva
of *O. fragilis*

Ophiothrix fragilis, the Common
Brittle Star

of the rays are used to drag the valves apart. Once the oyster has been forced to relax its muscles and permit the valves to open, the Starfish inserts the edge of its stomach between the gaping shells, and applies it to the soft body of the oyster, which is soon completely digested. The fisherfolk, who, very naturally, cordially detest the Starfish, not only on account of its love of oysters, but because of the way it will suck the bait from the hooks on their fishing-lines, are often given to tearing their foes asunder and flinging the halves back into the sea, a proceeding which does not always accomplish the destruction of their ancient foes, but may actually lead to an increase in their numbers, for the Starfish has most remarkable powers of replacing lost parts, so that the two halves thrown back into the sea are quite capable of growing into two complete Starfishes.

Besides the Common Starfish (*Asterias rubens*), which we have just been considering, there are a number of others belonging to the same division of the Echinoderma (the *Asteroidea*) to be found round our coasts, which offer many points of interest. It is only possible to draw attention to one or two of them here. A very pretty Starfish, comparatively rare between tide marks, but more frequently brought up in the trawl, is the Rosy Cribrella (*Cribrella* (*Henricia*) *sanguinolenta*). Its five rounded, tapering rays have on their under surface narrow ambulacral grooves, while the tube-feet are arranged in two rows. The eggs are large, and the larvæ do not swim at the surface of the sea, but glide about for a short time only at the bottom, their development to the adult form being very rapid in its progress.

The Common Sun-Star (*Solaster papposa*), although, as its name denotes, an abundant form, is nevertheless one of the handsomest of our British Starfishes. Both this and the Purple Sun-Star (*Solaster endeca*) have gained their popular name from their general appearance, which resembles a conventional painting of the sun, as it is generally depicted upon the signboard of a wayside inn. In the Common Sun-Star the short, stout rays number from twelve to as many as fifteen, surrounding the flat body-disk as a regular fringe, while in the Purple Sun-Star they number nine to eleven.

At low tide on the south and west coasts of England the interesting little Gibbous Starfish (*Asterina gibbosa*) may often be

found on the under sides of rocks, feeding upon various organisms attached thereto. It is quite a small Starfish, a large specimen rarely exceeding an inch across the body. In shape it is like a tiny, five-cornered cushion, for the rays are quite short and blunt, with very narrow and deep ambulacral grooves. The colour varies a good deal, generally of a greenish-yellow hue; it may be tinged with red or brown. A most extraordinary cushion Star is the Bird's-foot Sea-Star (*Palmipes membranaceus*), which looks almost like the webbed foot of some sea bird, it is so thin, flat, and flexible. Though rare as a shore specimen, it is by no means uncommon in deep water near the coast, and is frequently brought up in the dredge. It attains to some 5 or 6 inches in diameter.

The Butthorn Starfish (*Astropecten irregularis*) and the Lingthorn (*Luidia fragilissima*) are two very interesting Starfishes belonging to a family the members of which have their tube-feet destitute of suckers, and have no anus. The loss of suckers renders it impossible for the Butthorn Starfish to climb over the rocks, or to force open the valves of shell-fish like the ordinary Starfish; but by means of its pointed tube-feet it can move rapidly over the hard, smooth surface of the sand, where it lives, and as it has a wide and capacious mouth, it simply swallows its victims whole. The Lingthorn has long, flat, and rather slender rays, from five to seven in number. Of its tiresome propensity to break up voluntarily into fragments, making it a most difficult specimen to collect in a perfect condition, Professor Forbes gives the following amusing account: "The first time I ever took one of these creatures I succeeded in getting it into the boat entire. Never having seen one before, and quite unconscious of its suicidal powers, I spread it out on a rowing bench, the better to admire its form and colours. On attempting to remove it for preservation, to my horror and disappointment I found only an assemblage of rejected members. My conservative endeavours were all neutralised by its destructive exertions, and it is now badly represented in my cabinet by an armless disk and a diskless arm. Next time I went to dredge on the same spot, determined not to be cheated out of a specimen in such a way a second time, I brought with me a bucket of cold fresh water, to which article Starfishes have a great antipathy. As I expected, a *Luidia* came up in the dredge, a most gorgeous

specimen. As it does not generally break up before it is raised above the surface of the sea, cautiously and anxiously I sank my bucket to a level with the dredge's mouth, and proceeded in the most gentle manner to introduce *Luidia* to the purer element. Whether the cold air was too much for him, or the sight of the bucket too terrific, I know not, but in a moment he proceeded to dissolve his corporation, and at every mesh of the dredge his fragments were seen escaping. In despair, I grasped at the largest, and brought up the extremity of an arm with its terminating eye, the spinous eyelid of which opened and closed with something exceedingly like a wink of derision."

The second class of the Echinozoa comprises the Sand and Brittle Stars, creatures with disk-like bodies and long, slender rays, or arms, and the scientific name of the class, **Ophiuroidea,**[1] which literally signifies "snake-tail," not only expresses the dominating feature of their organisation, but also describes the writhing, snake-like movements of the long, slender arms by which the animals move along and climb over the rocks. The long, snaky arms of the Brittle Stars are attached to a small and usually rounded body-disk, to which the viscera are confined. The top and sides of the body-disk generally bear various sized plates, more or less covered with granules, spinelets, or groups of spines. In different species, the precise manner in which the plates on top of the body-disk are arranged varies, but five pairs of plates, called the *radial shields*, are always present, though not always clearly visible. Each pair corresponds to the base of one of the rays, one plate lying on either side of the ray, near the edge of the body-disk. This is usually, but not always, notched for the arm-bases, that dovetail, as it were, into the disk, and are visible on its under side, separated from one another by groups of regularly arranged plates, which converge towards the central mouth. Each arm-base is separated from the plated interradial areas at its sides by slitlike openings, which are usually single, occasionally double. They are called the *genital slits*, and lead into thin-walled pouches at the sides of the rays, and apparently have a double function, serving as respiratory organs, and for the reception of the ripe ova, which may be either at once discharged,

[1] The name of this class is derived from three Greek words: *ophis*, snake; *oura*, tail; and *eidos*, form.

or retained within the pouches to undergo a direct and rapid development.

The mouth is surrounded by twenty tentacles, two on each side of each oral angle, which is pierced for their passage. These tentacles, which in the living Brittle Star are kept in constant movement, are merely the modified tube-feet of the two first arm-joints adapted to assist the entry of food into the mouth, and the dispersal of the undigested residue, which is ejected from the mouth, there being no second or anal opening to the stomach as in the Common Starfish. The rays or arms of the Brittle Stars are rather appendages of the body than actual portions of it, as is the case with the Asteroidea. The greater part of each ray is formed by a central bony axis, which is composed of successive joints, and fills up almost the whole of the internal cavity of the ray. In the Ophiurids the tube-feet have less to do with locomotion than those of the Sea Urchins and Starfishes; their chief function is probably respiratory, locomotion being effected by the undulating writhings of the slender arms. Both the Brittle Stars and the Sand Stars are much more active than the true Starfishes, the Brittle Stars keeping their rays in constant wriggling movement. As their popular name denotes, they have a habit of breaking their rays into fragments if alarmed, roughly handled, or unwell, but the so readily discarded limbs are always replaced by new ones after a shorter or longer interval.

The Sand Stars, as may be gathered from their popular name, frequent sandy places on the floor of the sea, while the Brittle Stars frequent the same situation and also the deep rock pools low down on the shore towards low-tide mark. Many are abundant in the neighbourhood of oyster beds and scallop banks, possibly preying upon the "spat" at the season when it is ejected from the parent bivalves, though their stomachs generally contain minute shells of various foraminifera.

While most Ophiuroidea have simple, undivided arms, the members of the order **Astrophytida** [1] are exceptions to the rule, their arms forking ten or twelve times, so as to form a regular network of branches round the body disk. The rare and beautiful Shetland Argus (*Astrophyton scutatum*—Link), which may measure

[1] Greek, *aster*, star; *pheston*, plant; *eidos*, form.

a foot or more in diameter, is an interesting example of these branching, rayed Stars.

The third class of the Echinozoa, the **Echinoidea,** comprises the Sea Urchins, globular or disk-shaped animals with a skeleton forming a compact cuirass of plates of carbonate of lime, except for a space around the mouth and anus (the *peristome* and *peri-proct*) ; the anus, generally situated at the aboral pole, in some cases is displaced towards the side, or on to the ventral surface. The animals have gained both their popular and scientific names from the forest of long spines with which their bodies are covered. These spines are jointed on to low bosses or knobs on the closely fitting plates of the test or shell, and are chiefly disposed in five broad zones extending from one pole of the animal to the other. Alternating with these are five narrower zones, on which the spines are not quite so plentiful ; they are pierced with small holes through which the long, slender tube-feet, that are provided with terminal suckers, are extended. The Urchin uses the tube-feet for crawling and climbing over the rocks, the spines also being brought into play and acting as levers in tilting the body, and they are also used by the Urchin when walking over flat ground, the animal progressing by a kind of tilting motion. The five narrow zones bearing the tube-feet are comparable to the ambulacral grooves on the surface of the arms of the starfish. The spines have somewhat cup-shaped bases which are inserted on the projecting bosses, or *tubercles* as they are called, of the plates forming the test or skeleton, and they are connected to the tubercles by cylindrical sheaths of muscular fibres, the contraction of which causes their movement in any direction. Scattered throughout this forest of spines are numerous pedicellariæ, much more highly developed, however, than those of any starfish.

On the Common Sea Urchin (*Echinus esculentus*) four varieties of pedicellariæ are present : (1) *Tridactyle pedicellariæ* which are large and conspicuous, with three pointed jaws armed with two rows of teeth along their edges, and scattered over the whole surface of the body ; (2) *Gemmiform pedicellariæ*, having a somewhat globular, translucent head, due to each jaw having on its outer surface a sac-like gland which secretes a poisonous fluid, the virulence of which " may be gauged from the fact that the bite of a single Gemmiform pedicellaria caused a frog's heart

to stop beating." [1] (3) Very small *Trifoliate pedicellariæ*, with leaf-shaped jaws, the broad ends projecting outwards. (4) *Ophicephalous pedicellariæ*, the jaws of which have broad, rounded distal ends, fringed with teeth, and bearing, as the name denotes, a resemblance to a snake's head. These highly specialised forms of pedicellariæ all have their special functions, either as cleaning organs for the removal of particles of dirt or small organisms which may fall upon the body, for the capture and paralysing of prey, and as weapons of defence against larger foes.

The five narrow, pierced zones through which the tube-feet are extended are known as the *ambulacral zones;* while the five broader zones which alternate with them and bear the larger or primary spines, are the *interambulacral zones.* All these zones converge towards the summit of the test, where in the rounded Urchins the anal opening is situated, and occupies a more or less excentric position within a space called the *peri-proct.*[2] This space is separated from the apices of the ambulacral and interambulacral zones by an outer and an inner ring of large plates alternately arranged. Those forming the inner ring, which terminate the interambulacral zones, are pierced by the ducts of the genital glands, and one is also pierced by the water-pores, thus representing the madreporite, which is the upper extremity of the water-tube of the starfish; while the plates of the outer ring are pierced by unpaired tentacles which terminate the water-vascular trunks, and are comparable to the ocular tentacles terminating the arms of the starfish.

In the rounded Urchins, and also the flat Cake Urchins, the mouth is provided with a very complicated masticating apparatus, consisting of twenty principal pieces arranged into a five-sided conical mass, called after the old philosopher who first accurately described it, and from its general resemblance to an Oriental lantern, "Aristotle's Lantern." In the centre of the whole dental pyramid are the five sharp teeth, the points of which fill and slightly project beyond the entrance to the mouth. They work in bony sockets that are connected by muscles with one another, and with the interior of the test. The gullet passes upwards through the "Aristotle's Lantern," and is continued into an elongated digestive tube, which exhibits no differentiation into

[1] Prof. MacBride, M.A., F.R.S.

[2] Greek, *peri*, round about.

stomach and intestine, but is coiled spirally around the interior of the test, to which it is attached by a mesentery. The water-vascular system presents certain modifications and anatomical differences from that of the common starfish, but, as its function is identical, a detailed description of its component parts is unnecessary.

The Common Sea Urchin (*Echinus esculentus*) may be dredged up all round the English coast, and in such sheltered inlets as the Clyde it may often be found stranded on the shore at low-tide mark, or in the pools. Wherever the coast is exposed, however, it will only be obtainable with the dredge from depths of 20 or more fathoms, where it is beyond the depth of wave disturbance. It may attain to the size of a very large orange, flattened on its under surface, tapering slightly towards the aboral pole. It is covered with spines, which are short in comparison with the diameter of the body, and are usually whitish, sometimes tipped with purple. The body is generally a brownish red or purplish colour. The Purple Egg-Urchin (*Echinus miliaris*) has long, purple spines, never attains to the size of the Common Urchin, and is frequently to be found in holes in the rocks projecting into the sea so as to form reefs and ledges accessible at low water. Whether these refuges are actually excavated, as has been somewhat hastily and dogmatically stated by some authors, would appear doubtful, and is a matter requiring more careful and accurate observation than it has yet received. As Mr. E. W. L. Holt, Scientific Adviser to the Irish Board of Fisheries, points out, one side of the cavity is not infrequently formed by calcareous algæ, in which instances it would appear as if the Urchin had wandered into the cavity and become imprisoned by the growth of the algæ.

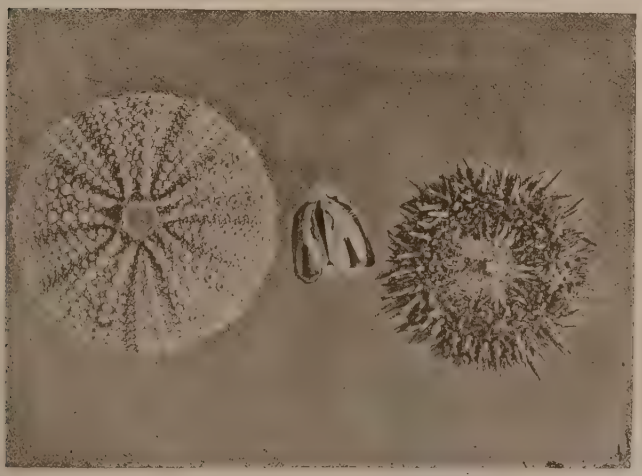
The *Clypeastrida*,[1] or Cake Urchins, are all extremely flattened in form, and have the anus (*periproct*) shifted from the apical pole to near the margin of the dorsal surface, so that it is no longer surrounded by the genital plates; and some of the tube-feet of the dorsal surface are flattened and modified into respiratory organs. They are all more or less sand dwellers, living half buried in the sand, or moving along its surface by the aid of their small locomotor tube-feet. All are more or less oval or circular in outline, and resemble, as may be guessed from their popular name, little flattish cakes.

[1] Latin, *clypeus*, a shield; Greek, *aster*, a star; *eidos*, form.

The Heart Urchins (*Spatangoidea*) have lost the "Aristotle's Lantern" altogether, the only trace of its former presence being a canal with membranous walls encircling the mouth, which has the form of a transverse slit, is situated near the front end of the test, and has the posterior lip projecting considerably forward. The anus is marginal or on the under surface of the test. In the Common Heart Urchin (*Echinocardium cordatum*) there are four distinct types of tube-feet, namely: (1) Respiratory tube-feet of the rays or petals of the upper surface of the test, which have no terminal sucker, and broad flat bases. (2) Prehensile tube-feet of the anterior ambulacrum, which when fully expanded are several times longer than the body of the Heart Urchin, and have curious frayed edges to their disks. (3) Buccal tube-feet, which are short, thick, pointed, and covered with numerous club-shaped processes. (4) Degenerate tube-feet, which are single, few in number, and issue from single pores of the test. The Heart Urchin is brown in colour, about 2 to 3 inches long, of an oblong oval shape, covered with fine spines. It forms a burrow in the sand some 8 to 10 inches below the surface, with which it communicates by a narrow, cylindrical opening. On wide, flat, sandy shores these curious Urchins may sometimes be seen emerging from their safe retreat near to low-tide mark, and making their way towards the incoming waves.

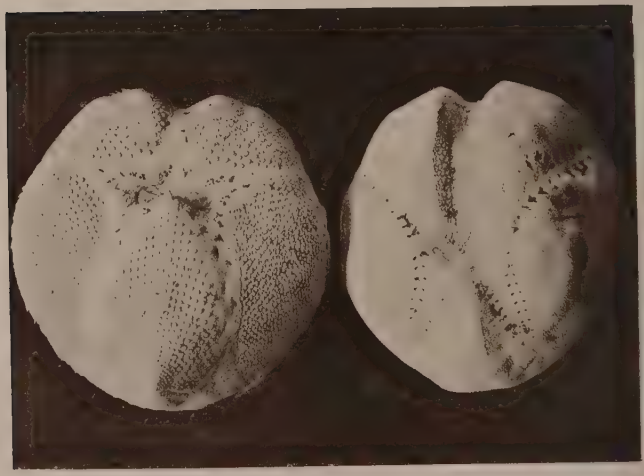
The fourth class of the Echinozoa contains the **Holothuroidea,** the Holothurians or Sea-cucumbers, all of which are creatures with more or less rounded, elongated bodies, having the mouth at one end and the anus at the other; while the ambulacral grooves, represented by closed canals, run from near the mouth down the length of the body to the proximity of the anus. The sausage-shaped body is enclosed in a tough skin, and the skeleton is reduced to more or less scattered spicules or plates, often very beautiful and regular in form. The gullet leads into a long, coiled digestive tube, which terminates in a large pouch or cloaca at or near the opposite extremity of the body. Round the mouth there is a fringe of branched tentacles connected with the water-vascular ring. In most of the Holothurians the water-tube which connects with the water-vascular ring hangs down freely in the body cavity and terminates in a sieve-like madreporite; but in a few species this is not the case, the water-vascular ring communicating directly

Sea Urchin with extended tube feet



Test and jaws of Echinus : *Echinus miliaris*

Heart Urchin (*Echinocardium cordatum*)



Tests of Heart Urchin; upper and under surface

with the exterior by means of a water-tube opening upon the surface of the body. The position and number of the tube-feet vary very considerably in different species; thus, in some five regular zones of tube-feet run from mouth to anus; in others those on the dorsal surface are modified; in others again the tube-feet may be scattered over the entire surface of the body; while in the worm-like Synapta and its allies they are entirely absent, the oral ring and tentacles connected with it being the sole representatives of the water-vascular system. The Holothurians move chiefly by the vigorous extension and contraction of their bodies, which are continually changing their shape by the action of strong muscles; and sometimes so forcible are the contractions that the whole of the viscera are ruptured and discharged through the cloaca, the animal living for a time without them, until it can make good the loss by growing a new set.

Some of the Holothurians grow to a relatively considerable size, their round, sausage-shaped bodies measuring over a foot in length, and being capable of very considerable further extension in the process of locomotion. Round our coasts they live among seaweeds, or in sand and mud, with the body concealed and the tentacles exposed. Certain large tropical forms, which abound on coral reefs in the Pacific, are called Trepang, or Bêche-de-mer, and are used as food, their capture and curing forming a quite important native industry. One of our British species is popularly called the "Cotton Spinner" (*Holothuria nigra*), from the cottony filaments which it discharges when irritated or removed from the water. It may attain to 1 foot in length when fully extended, and have a diameter of upwards of 3 inches. That side of its body which it keeps uppermost when crawling along is of a dark brownish green colour, while the lower side is a fine yellow.

The second division, or sub-phylum of the Echinoderma, the **Pelmatozoa,**[1] is of particular interest as representing a group of animals which are nearly extinct; indeed, out of its five classes only one, and that the most highly specialised, survives to the present day, though the others must have swarmed in the seas of past geological ages. This surviving class, the **Crinoidea,**[2] comprises the beautiful Feather Stars and their allies, the Stalked Crinoids, which are confined to very considerable depths of the

[1] Greek, *pelma*, a stalk; *zoon*, animal. [2] Greek, *krinon*, a lily; *eidos*, form.

ocean, and are rare; the Feather Stars, on the other hand, are comparatively common at depths of about 10 fathoms off the south-west coast of England.

In their mode of life the Crinoids differ entirely from all the other Echinoderms, for instead of crawling about mouth downwards, by the aid of tube-feet, they remain more or less permanently fixed in one spot, and mouth upwards, either growing on a stalk, or anchored by little clawed hooks to stones or seaweeds. The Stalked Crinoids, or Sea-lilies, which are the living representatives of the beautiful fossil Encrinites, or Stone-lilies, are very rare, but their structure is fundamentally similar to that of the more abundant and familiar Feather Stars. We will therefore take the Rosy Feather Star (*Antedon* (*Comatula*) *rosacea*) as our type. The body of this beautiful animal is star-shaped, with a central disk, and five arms, which divide almost at their base into two, so that the animal appears to be ten-armed. These arms are long and slender, very flexible, and clad with short, slender branches or pinnules, so that they look just like graceful feathers. Attached to the middle of the back of the body-disk are a number of little, jointed, clawed hooks, called the "cirri," by which the Feather Star anchors itself to any rock or weed on the floor of the sea. On the upper surface is the mouth, which may or may not be placed centrally; and the anus, the position of which is governed by that of the mouth. The upper surface of each arm and pinnule has a groove corresponding to the ambulacral groove on the arm of the starfish, but lined with cilia instead of tube-feet; and it is by the constant movement of the cilia that currents are set up in the water which carry tiny food particles along to the mouth, where the grooves of all the arms converge. Occasionally the Feather Star will swim about, probably changing its quarters in search of food, or a more favourable position, and then it moves through the water by very graceful undulations of the long, slender, feathery arms. The young escape from the egg as oval, free-swimming larvæ—a condition which lasts for a day or two—and then become fixed to a base by a slender stalk. The arms are developed, and the little animal looks like a miniature Sea-lily or Stalked Crinoid. Soon after the cirri, or anchoring organs, appear the young Feather Star snaps off its stem and swims away.

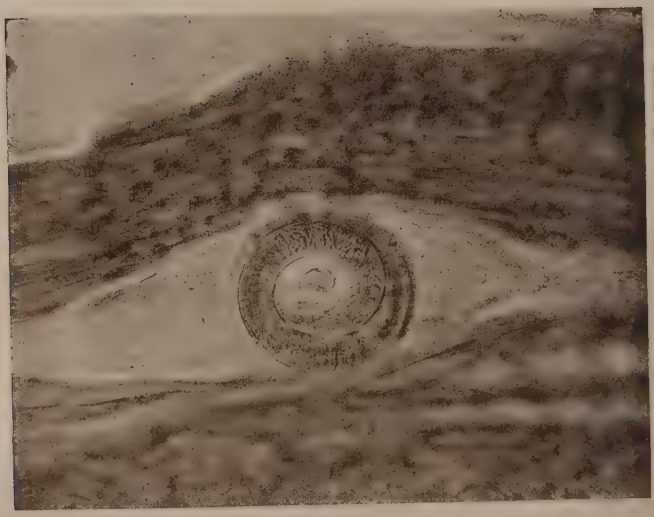
Holothuria nigra

Cucumaria normani

Synapta, a worm-like Holothurian

Auricula larva of Synapta

Leptoplana tremellaris



Trichina spiralis encysted in muscle

CHAPTER V

WORMS, ROTIFERS, LEECHES, POLYZOA

THE Worms comprise a great assemblage of animals of most diverse character and shape, leading the most varied lives, some dwelling in the sea, others in brackish and fresh water, others on land; while a whole host lead a parasitic existence in the tissues of human beings, in wild and domestic animals, birds, reptiles, and insects. To most people the vast majority are unfamiliar, if not absolutely unknown; nor can they be said to have any common characters by the possession of which they can at once be clearly distinguished from other animals. They are essentially an assemblage of animals of more scientific than popular interest, and have received more attention from the specialist than from the amateur. At the same time they are a very important group, and many of the marine forms are of extreme beauty and interest.

The lowest and simplest division of the group are the so-called **Flat-worms** (*Platyhelminthes*), which include the free Flat-worms (marine, fresh water, and terrestrial forms), the Flukes, and the Tape-worms. *Leptoplana tremellaris* is a common representative of the marine dwellers, often to be found buried in the mud, or under flat stones in the tidal pools, which has gained its name from the tremulous or quivering movements of its thin body as it swims along, the motion of the side expansions of the body somewhat resembling the action of a ray as it swims through the water. The body of Leptoplana is flat, soft, unsegmented, broader at the anterior end, tapering somewhat towards the posterior. It is brownish in colour, and measures from ¾ to 1 inch in length. Eggs are attached during the spring and early summer to stones and seaweeds, and the young hatch out in two or three weeks, and at first swim about in the surface waters until they are about 4 millimetres in length, when they are often very numerous

among the fronds of the seaweeds covering the rocks in the tidal pools. They are carnivorous in habit.

Leptoplana possesses a nervous ganglion or brain of oval shape, subdivided superficially into right and left halves by a shallow depression, and enclosed in a tough capsule. The eyes appear as a collection of small black dots lying at the sides of the brain, and the mouth is almost in the centre of the ventral surface of the body; no anal opening is present. Through the mouth, a frilled structure, called the pharynx, is protruded when the animal is feeding. This pharynx is supplied with salivary glands, which quickly soften and disintegrate the flesh of the prey, and the food then passes by way of the pharynx into the stomach and is there digested. From the stomach it passes into the lateral branches of the intestine, and finally the insoluble residue is discharged through the pharynx into the water.

The fresh-water Flat-worms prey upon water insects and pond snails, while the land forms have been observed to prey upon earthworms and snails.

The **Trematoda,** many of which are called "Flukes," are flat, rarely cylindrical, often leaf-shaped, or broad, bladder-like creatures, leading a parasitic life within or outside various animals. "Whilst some grow from large eggs, laid about the localities frequented by the parent, into the shape of the adult, others present the phenomena of alternation of generation, complicated by curious metamorphoses. These last kinds come from very small eggs which have got into water or damp places, and are at first very minute, contractile embryos, sometimes ciliated, which endeavour to settle on some animal or other, ordinarily some of the mollusca. This stage is that of the ciliated embryo. The ciliated embryo's office is to get on to a host; it then loses its cilia and becomes stationary on its host, and then gives exit to a cylindrical sac-like object, which has two lateral prolongations close to a tapering tail. At this stage of growth the parasite is called the *Redia*, and it has a mouth and a single intestine, but no other organs. Within this bag-like Redia a process of budding goes on, each bud becoming a creature like the parent of the ciliated embryo in shape; but it is destitute of reproductive organs, and is furnished with a long, flat tail like a tadpole, by which it is propelled after the escape from the Redia. At this stage

they are called *Cercariæ*. They burst forth, and, after a free-swimming existence, penetrate the body of some animal. They drop their tails and become encysted in the tissues. Finally they assume the adult form and develop reproductive organs, out of which pass the eggs. The Redia acts as the "nurse," and the Trematode may pass through life by inhabiting two very different animals after coming forth from that inhabited by the parent. The stages vary in different genera, and, as a rule, the first are passed in invertebrate and the last in vertebrate animals."[1]

The first sub-order of these Trematodes includes *Distomum* (*Fasciola*) *hepaticum*, the Liver-fluke of sheep, which produces the disastrous disease known as liver-rot. The appalling destruction for which these worms are responsible may be gathered from the fact that, in 1830, one and a half million sheep, representing something like four millions of money, perished from liver-rot in England alone; while in 1879–80 three million sheep died of this disease. The researches of Thomas and Leuckart have shown that the intermediate host is a small water-snail, *Limnæa truncatula*, and that the disease has a distribution as wide as the snail, throughout Europe, Northern Asia, North Africa, the Faroes, and the Canaries; while in Australia and the Sandwich Islands a variety of the Limnæa is the intermediate host. Low-lying meadows liable to flooding, and of damp, clayey soil, situations favourable to and where the *Limnæa truncatula* abounds, are naturally the most dangerous feeding grounds for sheep. The early larval and Redia stages are passed in the snail and a vast number of flukes (*Cercariæ*) developed, which, on leaving the snail, encyst upon the grass and are eaten along with it by the sheep.

Another closely allied Trematode, *Distomum hepaticum*, is parasitic in man, the horse, deer, goat, pig, rabbit, antelope, kangaroo, and many other animals. *Bilharzia hæmatobia* is a formidable parasitic Trematode, and a scourge among the natives of Egypt, the east coast and inland countries of Africa, along the shores of Lake Nyassa, the Zambesi River, and the Gold Coast; and is responsible for the very painful and serious disease called hæmaturia.

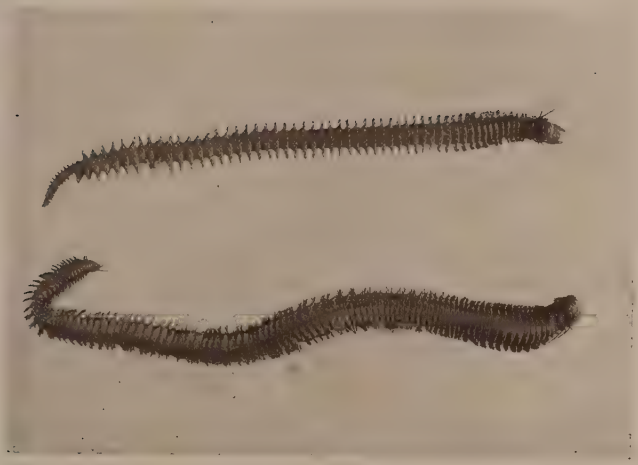
The **Tape-worms**, or *Cestoidea*, are parasitic within many vertebrate animals, including man, live in the intestinal canals of their hosts, and are readily recognised by their long, flat, many-

[1] Dr. P. Martin Duncan, F.R.S.

jointed bodies, narrow and small heads, usually armed with hooks and suckers suited for clinging on, and gradually narrowing tail end. They have no digestive system, but, living in the enteric canal of their host, absorb the contained fluids through the general surface of their body.

A Tape-worm consists of a long ribbon made up of innumerable segments or *proglottides*, the long body narrowing at one end into a rounded knob, the head or *scolex*. Upon the small head a circlet of hooks, borne on a rounded prominence called the *rostellum*, look like a little crown, and just behind are four oval suckers arranged at regular intervals. The jointed body, which may attain upwards of 20 yards in length, is generally separated from the head by a slender neck, from which the proglottides are segmented off, and become more individualised the farther they recede from the neck by the development of younger joints. All these proglottides in time develop sexual organs and produce ova, and as they mature break off from the rest of the worm, which still continues to grow. The head, or *scolex*, is really an anchoring organ and a kind of nurse; it is asexual and buds proglottides, which are reproductive. The detached proglottide has power of independent movement, so that it may either pass out along with the evacuations of the first host or make its escape by its own movements. In either case it will creep slowly on to some moist object near at hand, such as the stalks of plants and blades of grass, and is then devoured along with the herbage by some vertebrate animal; or should the proglottide fall into water, it bursts there, and the liberated eggs are swallowed by the animal drinking the infected water. In either case the eggs arrive in the stomach of a new host.

The embryos are minute, globular, naked vesicles, armed with microscopic hooklets, by means of which, should opportunity present itself, they will bore inwards into the tissue of their host, until finally the parasite reaches a small vein belonging to the portal system, and thence is carried by the flow of blood into the liver. Or, it may penetrate into other blood vessels and so get carried by the general circulation along to some other organ, to the brain, heart, or lungs. Wherever it finally becomes deposited it becomes encysted, and a new growth occurs, and by a process somewhat like budding, one or more bodies resembling



Nereis cultrifera

Arenicola marina

Two free swimming Rotifers

Melicerta, the so-called " Brick-maker " Rotifer

the head of the Tape-worm are developed, and on their escape, by the death of the host or by its being eaten by another animal, will become Tape-worms in the devourer. Thus the pig and the ox are the intermediate hosts for two Tape-worms commonly found in man, which develop in him as the result of eating the raw or only partially cooked flesh of infected animals. The so-called "measles" in pork is one stage of a disease produced by the encystment of the embryo or *cysticercus* of a Tape-worm, and if used for human food, unless submitted to prolonged and very thorough cooking, would certainly infect the consumer with this horrible parasite.

A Tape-worm that is parasitic in the cat passes its cysticercus stage in the liver of rats and mice, thus frequenting a situation highly favourable for its transference to the final host. Others, again, parasitic in birds, pass their cysticercus stage in the bodies of earthworms, frogs, snails, and water-fleas (Cyclops).

The **Thread-worms** (*Nematoidea*) are a group of round worms, mostly parasitic in habit, and usually possessed of a mouth, a swollen gullet, and a straight digestive canal. The cylindrical body is generally very long in comparison to its width. One of the most terrible parasites of man is a Nematoid worm called *Trichina spiralis*. In the adult or sexual condition it lives in the intestine of man, the pig, and other mammals. From the female worm, after impregnation, escape a vast swarm of minute young, which soon migrate through the walls of the intestine, reaching the voluntary muscles of the host, such as those of the tongue, back, and limbs. In this situation each worm enters a muscle-fibre, coils itself up in the muscle substance, becomes enclosed in a cyst, and the muscle undergoes more or less degeneration. If further development of the encysted and sexless Trichina worms is to take place, it is necessary for the infected flesh of the host to be devoured by another animal in which the worm is capable of living, e.g. that of a pig by man, that of man by a pig or a rat. If this is accomplished, then the cysts are dissolved by the digestive juices, the worms escape, develop reproductive organs copulate, and the resulting young once again migrate into the muscles of the host, producing the disease as before.

Cobbold, who made a special study of these parasitic worms, demonstrated the enormous number of Trichinæ it is possible

for an animal to have within its muscles at one time, when he proved that 1 oz. of pig's flesh belonging to part of an infected animal which had been unfortunately eaten, and had produced an epidemic, contained no fewer than 80,000 worms.

The Miner's Worm (*Dochmius* (*Ancylostomum*) *duodenalis*) is a dangerous parasitic Nematode which attacks man, causing great harm by burrowing in the intestinal walls and destroying the capillaries. The fertilised eggs leave the host with the excreta, and in damp earth soon develop into larvæ. These eat voraciously for a time, undergo several moults, and then pass into a resting stage. They may then be carried by surface water into the drinking supply, and, being swallowed, come to rest in the small intestine of the host. By their presence in large numbers —hundreds, and in some cases thousands, existing in the same host—they produce profound anæmia, with frequently fatal results. It was this worm which caused serious mortality among the miners employed in the excavation of the St. Gothard Tunnel.

The Guinea Worm (*Dracunculus medinensis*) is another Nematoid worm parasitic in man in the Tropics. The female lives coiled up in the subcutaneous tissues of the host, usually in the legs, producing most painful sores, and may attain to a length of 4 mètres, though generally it is between 18 and 20 inches. The body of the adult female is completely occupied by a uterus crowded with a great number of eggs and embryos, which can only escape by the actual rupture of the mother's body. This is one of the dangers to be guarded against during the process of extracting the worm from the tumour it has produced, which is accomplished by carefully winding the body of the worm, very slowly, round a piece of stick or a pencil, only an inch or two being withdrawn each day. Should the body, through careless or unskilful handling, be ruptured, the contained embryos will be set free and may result in the death of the host. The embryos, if they can escape into water, enter the body of the so-called water-flea or cyclops, and are likely to be reintroduced into their human host with the drinking of unfiltered water. The "gapes" of fowls and the so-called "grouse disease" are produced by Nematoid worms. To the same group belong the Lung-worms, often fatal to calves and lambs, and the Thread-worm (*Oxyuris vermicularis*), which is a troublesome and common parasite of children.

The **Rotifera**, or Wheel Animalcules as they are often called, are a group of microscopic animals which bear certain general features of resemblance to the *Trochosphere*, a characteristic larval form of a great group of worms, the Annulata, to which the Earth-worms, the marine Segmented Worms, and the Leeches belong. Minute as they are in size, the Rotifers are relatively highly organised animals, occurring abundantly in fresh water, less numerously in the sea, while they have a world-wide distribution. The majority are free-swimming, movement being effected by cilia confined to the front or oral extremity of the body and borne on what is called the *trochal disk* which is a very characteristic organ of the group. The motion of the stout cilia is such as to give to the trochal disk the appearance of a rapidly rotating wheel, and it is from this appearance that the animals have derived their name of Rotifera, or "Wheel-bearers." The trochal disk is not always circular in form, but may be divided into almost petal-like lobes, or be drawn out into long processes.

The body of a Rotifer is usually distinguishable in two parts, a body and a tail, the latter being frequently divided by a series of freely movable joints into a number of tubular segments, and provided at its extremity, in many forms, with a pair of rather forceps-like processes, by which the Rotifer can temporarily anchor itself to any object. The head is crowned by the trochal disk, and the mouth, which is a funnel-shaped cavity, may be in the centre or on one side of the disk. The walls of the funnel-shaped mouth are ciliated, and lead down to a muscular pharynx provided with peculiar movable jaws for the grinding up of the food particles before they enter the stomach. Food, in the shape of very minute organisms and particles of animal and vegetable matter, is carried to the mouth by the action of the cilia and the currents they produce. The sexes are distinct, the males being nearly always much smaller and degenerate in structure; the females are usually viviparous, or carry about the eggs until they are hatched. The eggs are of two kinds, and are termed summer and winter eggs; the former may develop without fertilisation,[1] while the fertilised eggs are thick-shelled winter or resting eggs, and can resist considerable heat, cold, and draught.

The Rotifers are sufficiently familiar objects to every one who

[1] Development without fertilisation is known as *parthenogenesis*.

has had an opportunity of looking through a microscope at a "pond-life" exhibition, for they are very favourite objects with every amateur microscopist. The fixed forms are particularly beautiful, the magnificent *Stephanocerus* (the so-called "Crown Animalcule") and the interesting little Brick-maker (*Melicerta ringens*), which forms a tube of rounded pellets of its undigested food, being two striking though familiar examples.

The **Gephyrea** are a group of marine worms with more or less bolster-shaped bodies rather resembling at first sight the Holothuria, and appear to occupy a position near the Annelida, or segmented worms. Their bodies are cylindrical, long, without distinct separation into segments, and without any lateral bristles. They live at varying depths, with their bodies buried in the sand or mud, or hidden under rocks, in the shells of molluscs, or the interstices between corals. Many species have a more or less retractile proboscis terminated by the mouth. The sexes are separate, and the young undergo metamorphoses, the larvæ often resembling the rotifera in their circles of cilia.

The **Annelida**[1] (or **Annulata**), or Segmented Worms, are a great assemblage of marine, fresh-water, and terrestrial worms, including the Earth-worms, the marine Segmented Worms, and the Leeches. All are characterised by the possession of bodies divided into a series of segments or rings, upon which bristles, either on processes called "false-feet" (*parapodia*) or in depressions in the tissues of the skin, are present; and internally by a spacious cavity or cœlom between the body-wall and that of the digestive tube. Presenting great differences in structure, the Annulata are divided into two great orders, the Few-bristled Worms (*Oligochæta*) and the Many-bristled Worms (*Polychæta*), and the Leeches or Suctorial Annelida, which form a sub-order to themselves.

The **Few-bristled Worms** (*Oligochæta*) are long worms with segmented bodies, and are dwellers in the earth, in oozy mud, and at the bottom of ponds and streams. Their scanty supply of bristles are never borne on false-feet or parapodia; they have no tentacles, do not pass through a metamorphosis, and are all hermaphrodites (i.e. the same individual possesses both male and female reproductive organs). The **Many-bristled Worms** are dwellers in the sea; they all have numerous bristles

[1] From the Latin, *annulus*, a ring.

carried on false-feet or parapodia, possess tentacles, cirri and branchiæ, undergo a metamorphosis, and have the sexes separate. The **Leeches** (*Hirudinea*) are dwellers in fresh water, frequenting ponds and streams, and also live in the sea, and in moist situations on land. They have oval bodies, somewhat resembling an earth-worm's, and generally possess two suckers, one at each end of the body.

The Common Earth-worm (*Lumbricus terrestris*) belongs to the Few-bristled Worms (*Oligochæta*), and is such a familiar object as to call for little description here. Although the Earth-worms are so common, they are not only very interesting, but they are also very useful animals, for they are Nature's ploughmen, for ever at work turning the soil, and are the principal agents in the formation of that vegetable soil which is so valuable to the agriculturist. What they are capable of accomplishing we begin to realise when we come to examine the results obtained by Darwin in his long and patient observations, which enabled him to demonstrate that an acre of garden has, on an average, a population of 53,000 worms, through whose bodies some 10 tons of soil pass annually.

Gilbert White of Selborne must also have watched and meditated much upon the doings of the earth-worms in his garden, for he has left us in his writings the following eloquent testimonial to their vital importance to the land: "Earth-worms, though in appearance a small and despicable link in the chain of Nature, yet, if lost, would make a lamentable chasm. . . . Worms seem to be the great promoters of vegetation, which would proceed but lamely without them, by boring, perforating, and loosening the soil, and rendering it pervious to rains and the fibres of plants, by drawing straws and stalks of all kinds into it; and, most of all, by throwing up such infinite numbers of lumps of earth. . . . Worms probably provide new soils for hills and slopes when the rain washes the earth away. . . . The earth without worms would soon become cold, hard-bound, and void of fermentation, and consequently sterile."

The body of the Earth-worm is divided up into a series of rings or segments, and tapers at both ends to a blunt point. Slightly in front of the middle part of the body there is a thickened area extending over five segments and called the "saddle," or

clitellum, while a double row of minute bristles extend along the under surface of the body. The reproductive organs are hermaphrodite, there being two male ducts and two female ducts, opening on the ventral surface of the fifteenth and fourteenth segments. The body cavity is divided by cross-partitions into segments corresponding to the external rings; while the food canal is divided into several parts, comprising a muscular pharynx for grasping leaves or stones, a gullet, a crop, a gizzard or mill for grinding up the swallowed soil, and a long digestive part. A pair of small kidney-tubes, or *nephridia*, are present in almost every segment, and represent the excretory system. The fertilised ova are enclosed in a cocoon, the wall of which is composed of a viscid secretion from glands on the saddle or *clitellum*. This cocoon is deposited in the earth, and the embryos develop within it into perfect minute worms ere they make their escape. The Earth-worms are very widely distributed, and some of the tropical forms attain to a very considerable length and thickness.

The Many-bristled Worms (*Polychæta*) are highly developed marine worms, varying greatly in appearance and habit, and are divided into two sub-orders, namely, those leading a wandering life and having well-developed false-feet or parapodia, which comprise the **Errantia**, and those having feebly developed parapodia and dwelling in protective tubes, which comprise the **Tubicola**.

"In examining these Many-bristled Worms it is advisable to employ certain descriptive terms. Thus, the first segment of the body is called the *prostomium*, and the mouth opens on it; the second is the *peristomium*. When the three front segments are united, or when they differ from those which come after, they are called the head or cephalic segments; but when this is not the case the worm is said to be acephalous. The head has various appendages, according to the genera. Antennæ are soft filaments varying in number from one to five, and they arise directly from the head, are not retractile, and are usually jointed at the base. The tentacles are soft, bristly, or thread-shaped, non-retractile processes, which arise from each side of the segments of the head in pairs, and spread laterally; they are often very long, and are contractile in the acephalous genera. The mouth is underneath the head, and is a round or transverse opening to the gullet.

It has usually a plain margin. In the acephalous genera it is terminal, and has external tentacles, but there are no jaws, and in the cephalous it is nearly terminal and looks forward horizontally. It is almost always furnished with a proboscis in the cephalous tribes; that is to say, the œsophagus or gullet can be protruded. It consists of two segments, and can be put forth at pleasure by a process of turning inside out. It is often armed with horny jaws, in opposite pairs, or is roughened on the surface with horny prickles; or it may be covered with pimples or be plain. The head is succeeded by the "thoracic segments," and in the cephalous genera there is but one of them. It is naked and has no appendages. But in the acephalous genera and some of the others the thoracic segments are distinguished by peculiarities in their structure and appendages. They may be fleshy and contain most important organs, and the branchiæ are often limited to them. The abdominal segments complete the body, vary in number, are alike, and lessen in size, the last being the anal.

"The so-called foot, or *parapodium*, is a pimple-shaped projection on either side of a segment. It supports the bristles, which are, as it were, sheathed by it, and it is a basis of attachment for the branchiæ and soft, setaceous filaments, called cirri, resembling tentacles. The foot may be in one lobe, or there may be two lobes; one upper or dorsal, and the other lower or ventral. These lobes, also called branches, are more or less apart, and when there is but one branch or lobe the foot is said to be *uniramous*, and when there are two *biramous*. The branchiæ in the cephalous worms are attached to the base of the foot on the upper or dorsal side, and are either restricted to a certain number of segments or they are found on all. They are either arborescent, combed on one side, flat, and veined, or they may be filamentary." [1]

It will be seen from the above outline of some of the anatomical details that the Polychæta are highly specialised animals. They are very numerous, have a wide geographical distribution, and are most interesting creatures. The majority of the Wandering Worms, or *Errantia*, are active, predatory animals, have a distinct head, carrying eyes, tentacles, and usually tentacular cirri.

Most visitors to the seaside are familiar with the little mounds

[1] Dr. P. Martin Duncan, F.R.S.

of sand ropes which dot the shore when the tide is out, and have also probably noticed that it is where these little mounds are most plentiful that the fishermen go to dig for bait for their lines. The men are digging up the worm which produced the mound, and which is called the Lug Worm (*Arenicola piscatorum*). It is a long, cylindrical worm, sometimes measuring 10 or 12 inches in length, and is generally of a blackish-green colour, the tint varying with the locality in which the worm is found. The front part of the body is somewhat swollen, and thirteen of the body segments bear beautiful red arborescent branchiæ. The worm lives in a burrow which it has literally eaten in the sand at a depth of about 2 feet from the surface, its position being readily detected by the spiral ropes of sandy excrement coiled about the entrance of the burrow.

Visitors to a wide sandy shore at low tide may sometimes be rewarded by finding a specimen of the beautiful *Aphrodite aculeata*, a singularly unwormlike animal, popularly called "the Sea Mouse." It is fairly common on the south coast of England, and frequently attains the length of 8 or 10 inches. The body is oval in outline, and the numerous feet bear long bristles which flash back all the glorious colours of the rainbow in the sunlight, while the back is covered with a dense coat of fine mouse-coloured bristles, from which the worm has gained its popular name of "Sea Mouse." This soft felting hides from view a series of scales or elytra with which the back is covered. The Aphrodite burrows in the sand as the tide goes out, and remains safely hidden from view until about a quarter of an hour before the tide turns, when, as if impatient for the return of the sea, the little animal comes to the surface, thickly coated with sand, and proceeds slowly down towards the incoming waves.

The **Nereidæ** are a very numerous family of marine worms, with long, slender, segmented bodies and flat heads, and two small and two large feelers on each side of the mouth. The pharynx is protrusible; there are two large, horizontally moving jaws, and the parapodia are double and have sharp spines. Specimens are frequently to be found hidden under flat stones at low-tide mark on the seashore. The Red Cat Worm (*Nereis diversicolor*) is a familiar example, taking its name from its varied tints and growing to a length of about 10 inches. It is a predaceous

worm, seizing its prey by means of a pair of sharp, hooked jaws. The White Cat Worm (*Nephthys margaretacea*), which measures from 6 to 10 inches in length, lives in rather firm sand between half- and low-tide mark, and has a beautiful pearly lustre. Many species of Nereis undergo considerable modification of form as they become sexually mature, those segments containing the generative products becoming greatly changed in appearance, while the front part of the body remains comparatively unaltered. So great is the change in appearance, that the mature worms were for a long time supposed to belong to a different genus, and were called *Heteronereis*, a term which is now retained to designate this particular stage in the life of the worm. In this heteronereis stage the males have fewer unaltered anterior segments than the females.

A species also known locally as the "Red Cat Worm" (*Nereis cultrifera*) is fairly common on our southern coasts, where it attains a length of 6 inches. The illustration facing page 76 shows the formidable jaws of this worm, and in shape it very closely resembles *N. diversicolor*.

A most remarkable little Nereidiform Worm is the *Tomopteris scolopendra*, with its hammer-shaped head and long antennæ. At certain seasons it is not at all uncommon off our shores, where it is frequently taken in the naturalist's tow-net.

The **Phyllodocidæ**, or Leaf-bearing Worms, are easily distinguished from all the other Annelids by the double row of leaf-like cirri on each side of the body, forming a border immediately above the insertion of the feet (parapodia). The Leaf-bearing Worms are swift in their movements and very graceful swimmers. The Paddle Worm (*Phyllodoce laminosa*) is generally a bright bluish or yellowish-green colour, and may grow to 24 inches in length. During the daytime it lurks under stones and old shells, coming forth at night to seek its prey. Many of the marine worms become phosphorescent at night, glowing with a bright and steady light, and one of the most interesting examples is the extraordinary Vari-footed Worm (*Chætopterus variopedatus*), figured facing page 89, which shines with a strong greenish or azure-blue light, and builds a long U-shaped tube in which to live, composed of a parchment-like substance coated externally with sand and small stones.

All the **Tube-building Worms** are beautiful and interesting creatures, and of one of these, the *Sabella*, Sir John Dalyell has left among his writings the following description: "Let a tall and ample crystal jar containing a *Sabella* be emptied of its contents and speedily replenished with sea-water; the animal, if in view, has retreated during the short interval; the orifice of the tube is closed; all is at rest. But soon after replenishment it rises, to display its branchial plume still more vigorously than before, and remains stationary, as if enjoying the freshness of the renovated element, always so grateful—the harbinger of health and strength to those whose dwelling is there. The passing spectator would conclude that he now beholds only a beautiful flower, completely expanded, inclining towards the light like some of those ornaments of Nature decorating our gardens. He pauses in admiration. But if a drop of liquid mud falls amidst the element from above, disturbing its purity, then, while the plume unfolds to its utmost capacity, does the animal commence a slow revolution, the body also passing around within the tube. Now are the thousands of cilia fringing the ribs of the branchiæ discovered to be in vigorous activity, and their office to be wondrous. A loose muddy mass is soon afterwards visibly accumulated in the bottom of the funnel; meantime the neck, or first segment of the body, rising unusually high above the orifice of the tube, exhibits two trowels beating down the thin edge as they fold and clasp over the margin, like our fingers pressing a flattened cake against the palm of the hand.[1] During these operations muddy collections are seen descending between the roots of the fans towards the trowels; while another organ, perhaps the mouth, is also occupied, it may be, in compounding the preparation with adhesive matter. Still does the partial or complete revolution of the plume above, and of the body within the tube, continue; the bulk of the muddy mass diminishes, activity abates; it is succeeded by repose, when the tube is found to have received evident prolongation."

Amphiglena mediterranea is a handsome little worm, only ¼ inch long, and when seen alive under the microscope is very beautiful, its plume-like gills, clad with a double row of ciliated processes,

[1] This refers to the curious lappets of the peristomial collar.

presenting a very animated sight. It is a sabelliform worm and hermaphrodite.

Another interesting tube-builder is a worm that is sometimes called the Shell-binder (*Terebella conchilega*), which builds a wonderful tube that looks almost like a miniature tree, with its trunk and stunted branches coated with sand, tiny pieces of shell, and very small pebbles. The worm has a large number of long and slender tentacles, which it uses for the capture of prey and for collecting the particles of sand in the process of building its tube. Each tentacle has a groove along one side, and particles of sand or food are conveyed along this furrow to the mouth. Every sand grain used in the construction of the tube is in this way conveyed to the mouth, where it is coated with some natural secretion, and then worked into place by means of the worm's lips at the edge of the tube.

The pinkish, rounded, shelly tube of the Serpula Worm (*Serpula vermicularis*) is often to be found adhering to an old whelk shell, or on a rock in some tidal pool. It is about 3 inches long, tapers regularly backwards, and is marked on its dorsal surface with a more or less distinct keel, while the worm is only about 1 inch in length. It is a very beautiful little creature, with graceful and richly coloured branchiæ, consisting of most elegant comb-like filaments arranged in two rows, one on each side of the mouth. These filaments bear numerous cilia, the movements of which set up currents in the water, and in this way particles of food are caught and carried down to the mouth. Occupying a position nearly central to the surrounding comb-like filaments is a long, slender stalk, terminating in a conical, bright-hued organ, the *operculum*, which acts as a stopper, most effectually closing the entrance of the tube when the worm retires within its shelter. When alarmed, the Serpula withdraws within its tube with lightning-like rapidity, its swift retreat being accomplished by a most remarkable mechanism consisting of a series of bands provided with a multitude of microscopic hooks which engage in the lining of the tube. Gosse, who made a careful study of Serpula, gives the following description of these organs : " This yellow line, which cannot be appreciated by the unassisted eye, is a muscular ribbon, on which stand up edgewise a multitude of what I will call combs, or rather sub-triangular plates. The edge of each plate is cut

very regularly into six teeth, which curve in one direction, and one other curved so as to face these. The combs stand side by side parallel to each other, along the whole length of the ribbon, and there are muscular fibres seen affixed to the smaller end of every plate, which doubtless give it independent motion. I counted 136 plates on one ribbon; there are two ribbons on each thoracic segment, and there are seven such segments—hence we may compute the total number of prehensile comb-like plates to be about 1,900, each of which is wielded by muscles at the will of the animal; while, as each plate carries seven teeth, there are between 13,000 and 14,000 teeth hooked into the lining membrane of the cell when the animal chooses to descend. No wonder, with so many muscles wielding so many grappling hooks, that the retreat is so rapidly effected!"

The **Leeches** (*Hirudinea*), or Suctorial Annelida, are worm-like creatures, frequenting both fresh and sea water, with segmented bodies bearing a flat disk at each end. The Medicinal Leech was formerly a familiar object to be seen in small aquaria in chemists' shops, and was used very largely by doctors for drawing blood from patients. Now that blood-letting is no longer a regular practice, the leech is rarely seen. The colour of the Medicinal Leech is olive or dark green, with six ruddy yellow bands along the back, while the abdomen is yellowish-green with black spots. On taking a leech out of the water it will contract its body and diminish in size. If placed on the hand, it will soon begin to fix its front sucker to the skin, a series of sharp pricks being felt as the sucker becomes firmly fixed. The leech now elongates and moves its body with a slightly undulatory motion. Gradually it becomes more and more distended, until it suddenly lets go its hold and falls off, gorged with blood. The banquet is followed by a prolonged fast, and the length of time that the animal will live without food is remarkable—from six months to two years. According to Cobbold, three species of leeches were formerly used in medicine, namely the Grey Leech (*Hirudo medicinalis*), the Green Leech (*Hirudo officinalis*), and the Dragon Leech (*Hirudo interrupta*).

All the leeches lay eggs, and they may be deposited singly or in numbers, and in the latter case they may be covered with a viscous web or with a spongy envelope called the cocoon. When

Part of a colony of *Flustra foliacea*

Part of a colony of *Bugula avicularia*

Chaetopterus varipedatus

Sabella pavonia

Lanice conchelegia

the young are hatched they remain within the cocoon for some twenty or thirty days before making their escape. They do not undergo a metamorphosis, and although in some species the sexes are separate, they are united as a rule. Of the marine leeches the Skate-sucker (*Pontobdella muricata*) is of interest as being the transmitting agent of a Trypanosome (*T. Raii*) from one ray to another.

There are a number of marine worms which, from their bolster-shaped bodies, resemble at first sight some of the Holothuria, or Sea-cucumbers, belonging to the Echinodermata Their bodies are usually long and cylindrical, destitute of parapodia or false-feet, and unsegmented. These animals comprise the **Gephyrea,**[1] and were so named by Quatrefages, who considered them as forming a bridge between the Worms and the Echinoderms. All are marine, and while some live in the shells of molluscs, others frequent the interstices between corals, or the sand and mud at the bottom of the sea. The sexes are separate, and the young undergo a metamorphosis.

The **Polyzoa** are a most interesting group of animals, chiefly dwellers in the sea, and, with one exception, form more or less extensive colonies. The most familar are the Sea-mats (*Flustra*), whose pale brownish, almost leaf-like colonies are to be found on every shore. They are known by several popular names, such as "Sea-mats," "Horn-wracks," "Moss-animals," and "Lace-corals," all terms more or less descriptive of their appearance; while to science they are known by two names, Polyzoa and Bryozoa, the latter being chiefly used by Continental writers. Polyzoa was the name given to these animals by the English naturalist J. V. Thompson, and has undoubted priority over the term Bryozoa assigned to them by C. G. Ehrenberg in Germany.[2]

Often very plant-like in their growth, it is not surprising to find that the Polyzoa were at first mistaken for seaweed, and later placed under the head of "Zoophytes" or plant-animals, before their real character was discovered. If we examine the leaf-like expansion of the Common Sea-mat (*Flustra foliacea*), we shall see

[1] Greek—*gephura*, a bridge.

[2] For a concise account of the controversy over these two names, *see* Hincks's "History of the British Marine Polyzoa."

that it is composed of hundreds of separate minute chambers, placed back to back, each rounded at one end, near which is the narrow opening through which the tentacles of the living animal are pushed. Each minute tenant of one of these cells has a sac-like or cup-shaped body within which can be seen by the aid of the microscope the bent U-shaped food canal; while around the mouth there is a beautiful wreath of tentacles. All the Polyzoa multiply by budding, and in this way the area and the number of individuals making up a colony increase; but the Polyzoa also reproduce sexually, the sexes being either separate or united. The young, or larvæ developed from the egg, are free-swimming, and become the founders of the new colonies.

The members of a colony are not always all alike, some of them being modified in a very remarkable manner, appearing as organs resembling a bird's head, or as a long whip-like lasher, and termed respectively the *avicularium* and *vibraculum*. The curious "bird's heads" are highly developed in the Bird's-head Polyzoa (*Bugula avicularia*), and present the most extraordinary appearance under the microscope. Beside the ordinary tentacle-crowned polyp members of the colony there are scattered over its surface a large number of these curious "bird's-head" organs, which look just like miniature vulture's heads mounted on slender, contractile necks which sway from side to side, and armed with sharp beaks which open and shut with a vicious and angry snap upon anything that comes within their reach. These organs and the slender lashers which replace them in certain species appear to act as cleansers, preventing sediment and many small creatures from settling upon the colony. The fresh-water forms of Polyzoa reproduce by curious winter-buds, called *statoblasts*, which are liberated on the death of the parent, are floated away, and after remaining dormant throughout the winter months develop into new colonies in the spring.

Very numerous in the seas of to-day, the Polyzoa flourished in the seas of past geological epochs, their beautifully preserved fossil remains being very plentiful in Silurian and all the more recent formations. Although some colonies of Polyzoa bear a resemblance to the Hydrozoa, it is but superficial, for the individual animals are much more complex in structure, and are independent of each other. *Cristatella*, *Lophopus*, and *Plumatella* are

beautiful fresh-water forms, to be met with in streams and lakes; but the most numerous and interesting forms are dwellers in the sea. As regards their exact position in the animal kingdom, opinions are somewhat divided, some zoologists considering them as related to the Mollusca, others to the Worms. The latter view has the support of such able embryologists as Agassiz, Steenstrup, Morse, and Kovalevsky, and is now the more generally accepted.

CHAPTER VI

THE MOLLUSCA

"See what a lovely shell,
Small and pure as a pearl,
Lying close to my foot,
Frail, but a work divine,
Made so fairly well,
With delicate spire and whorl,
How exquisitely minute—
A miracle of design!

* * * * *

Did he stand at the diamond door
Of his house in a rainbow frill?
Did he push, when he was uncurl'd,
A golden foot or a fairy horn
Thro' his dim water-world?"

ALFRED TENNYSON's exquisite lines bring to us, as we read them, a mental picture of golden sands and a sun-kissed sea, breaking in long, low, murmuring waves upon the shore, to scatter at our feet some of the treasures of the deep, shells of beautiful form and softest rainbow tint. And how often our first introduction to the shells of the animals with which this chapter deals is made during a holiday ramble on the seashore! Should our interest be aroused sufficiently by the specimens so collected to induce us to endeavour to find out something about the inhabitants of these delicately tinted shells, we very quickly discover that they are most interesting and wonderful creatures. Indeed, the Mollusca form one of the most important divisions of the animal kingdom, including more than fifty thousand known species, which live in the sea, in lakes, ponds, and streams, and upon land. The Phylum includes the Octopus and Cuttlefish, the Oysters, Whelks, Mussels, Scallops, Winkles, Snails, and Slugs, and is divided into four great orders: the *Cephalopoda*, or head-

footed molluscs; the *Gastropoda*, or stomach-footed molluscs, the univalves; the *Pelecypoda*, or axe-footed molluscs, the bivalves; and the *Scaphopoda*, or boat-footed molluscs, the tooth-shells. To these may be added a fifth order, the *Pteropoda*, or wing-footed molluscs, whose exact position is still somewhat doubtful, some authorities regarding them as a subdivision of the Gastropods, while others consider them as forming a separate order.

In the first order, the **Cephalopoda**, the feet (more popularly spoken of as "arms") are arranged symmetrically round the head or mouth; and the order includes the Octopus, the Argonaut or Paper Nautilus, the Cuttlefish, the beautiful Pearly Nautilus, and the fossil Belemnites and Ammonites. They are all marine, fairly active, and carnivorous. The Cuttlefish, Octopus, and Argonaut possess only two plume-like gills or breathing organs, while the Pearly Nautilus, sole survivor of a once very numerous order, possesses four.[1] The Nautilus and the Argonaut are the only living representatives of the Cephalopoda that have an *external* shell, the other members having an internal "shell" hidden in the soft part of their body (*Sepia*, *Loligo*). Those members of the Cephalopoda possessing eight arms are termed the *Octopoda*, while those with ten arms comprise the *Decapoda*.

The Argonaut, or Paper Nautilus, was known to the ancients, and described by Aristotle as floating on the surface of the sea in calm weather, holding up its two sail-shaped arms to catch the breeze, and sailing along like a miniature ship upon the bosom of the ocean. This pretty but absolutely false idea was generally accepted, and handed down through the centuries as an established fact. Artists and poets alike helped to popularise this myth, the former by depicting the animal with six arms extended over the sides of its frail shell to act as oars, and with the two other arms expanded and upraised to act as sails; while the poets would have us credit it with giving man his first lesson in navigation. Pope bids us—

> "Learn of the little Nautilus to sail,
> Spread the thin oar, and catch the driving gale."

The most charming poetic description of the mythic habits of

[1] Those Cephalopods having two gills form the order *Dibranchiata*, and those with four gills the *Tetrabranchiata*.

the Argonaut is that given by James Montgomery in his "Pelican Island":—

> "Light as a flake of foam upon the wind,
> Keel upward from the deep emerged a shell,
> Shaped like the moon ere half her horn is fill'd;
> Fraught with young life, it righted as it rose,
> And moved at will along the yielding water.
> The native pilot of this little bark
> Spread to the wafting breeze a twofold sail,
> And mounted up and glided down the billow
> In happy freedom, pleased to feel the air,
> And wander in the luxury of light."

Could any description be more dainty and delightful? Yet not one word of it, I regret to say, is true. The slender arms are never used as oars, while those which have the broad, expanded membranous disk are never used as sails, their real function being to clasp and secrete the fragile shell, depositing the necessary shelly matter for its repair should injuries arise. The Argonaut crawls about on the floor of the sea with its shell on its back in as prosaic a manner as a common garden snail; while, should it rise to the surface, it swims along backwards by ejecting water from its funnel, after the fashion of the Octopus and Cuttlefish. The male has no shell and resembles a small Octopus, the female alone secreting the shell, which serves as a receptacle for her eggs.

The members of the Octopus family have only an internal rudimentary and uncalcified shell, consisting of two short styles or plates, enclosed in the body. The eight arms which encircle the front of the head are long and tapering; they have two rows of disk-shaped suckers, and are united at their base by a broad, membranous web. The mouth is in the centre of the circle of arms, and contains a pair of jaws resembling somewhat in shape the beak of a parrot; they are not formed of bone, but of a hard, tough material of a chitinous character. The tongue or radula is a slender organ, small in comparison to the size of the animal, beset with rows of sharp-pointed teeth, and is used as a rasping organ to further break up the food that has been torn by the jaws. The head is large and the eyes staring, while the body is more or less bag-shaped, and, besides the digestive organs, con-

tains an ink-bag, the contents of which are ejected into the water by the animal when alarmed.

The Octopus generally spends the hours of daylight comfortably concealed in a rock cranny, or he may sit at the entrance to his grotto and fish for unwary crustaceans and other denizens of the deep that may pass within reach of his long arms. Normally, however, he does not start out to hunt his prey until the approach of dusk, when he issues forth from his cave like a veritable dragon of the deep, and steals silently and swiftly upon his unsuspecting victim. In a moment it is pounced upon and wrapped around by those long, writhing arms, from which there is no escape. The powerful beak-like jaws are buried in the quivering flesh of the victim, and the silent tragedy of the deep is soon ended. With the approach of dawn the Octopus steals, like some dark, evil shadow, back to his grotto to rest, and sleep the sleep of repletion.

One would hardly expect such formidable and forbidding creatures as the Octopus and Cuttlefish to be troubled with many foes desirous of seeking combat, or coming within reach of those writhing, sucker-clad arms, yet such is the case, and certain species of whales, giant congers, dogfish, and sharks eagerly hunt for and devour them. To enable them to steal unobserved upon their prey, and also in turn to escape the notice of their foes, both the Octopus and Cuttlefish have considerable powers of changing colour, so as closely to resemble the colour of their surroundings. When alarmed, the play of colour over the body and limbs of the Octopus is very rapid; while should it lose one or two arms in the course of an encounter, it has the power of replacing them with new ones in the course of time.

Mr. Henry Lee, F.L.S., who had exceptional opportunities of watching the habits of the Octopus when kept in large aquaria, gives the following interesting account of the spawning of the animal: "Our Octopus fortunately selected as a suitable site for her nest a recess in the rockwork, close to the front glass of the tank, so that her movements could easily be observed. Her body just filled the entrance to it; and she further strengthened its defences by dragging to the mouth of her cavern two dozen or more of living oysters, and piling them one on another to form a breastwork or barricade, behind which she ensconced herself. Over this rampart she peered with her great, sleepless, prominent

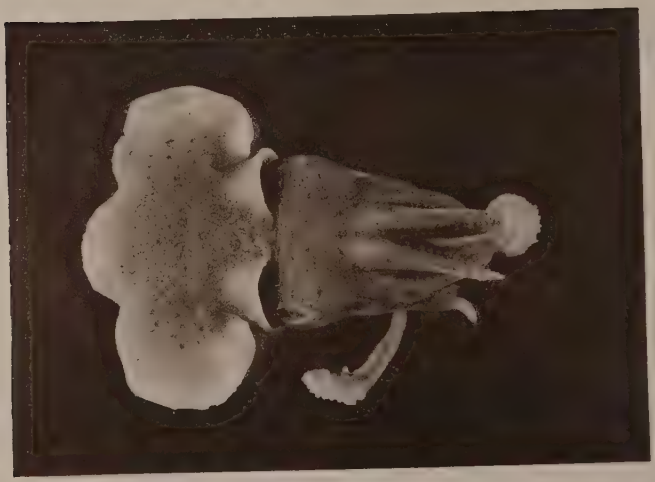
eyes ; her two foremost arms extended beyond it ; their extremities coiling and writhing in ceaseless motion, as if prepared to strike out right and left at any intruder. Her companions evidently felt that it was dangerous to approach an excited mother guarding her offspring, and none ventured to go within arm's length of her. Even her forlorn husband was made to keep his distance. If he dared to approach the lady roused herself with menacing air, and slowly rose till her head overtopped the barrier. A dark flush of anger tinged the whole surface of the body ; the two upper arms were uncoiled and stretched out to their utmost length towards the interloper ; and the poor, snubbed, henpecked father invariably shrank from their formidable contact, and sorrowfully and sullenly retreated, to muse, perhaps, on the brief duration of cephalopodal marital happiness. Our brooding French Octopus, when undisturbed, would pass one of her arms beneath the hanging bunches of her eggs, and, dilating the membrane on each side of it into a boat-shaped hollow, would gather and receive them in it as in a trough or cradle, exhibiting in its general shape and outline a remarkable similarity to those of the Argonaut or Paper Nautilus, with the eggs of which Octopod its own are almost identical in form and appearance. Then she would caress and gently rub them, occasionally turning towards them the mouth of her flexible exhalent locomotor tube, so as to direct upon them a jet of the excurrent water. I believe that the object of this syringing process is to free the eggs from parasitic animalcules, and possibly to prevent the growth of conferva, which I have found rapidly overspread those removed from her attention. Week after week she continued to attend them with the most watchful and assiduous care, seldom leaving them for a moment, except to take food, which, without a brief abandonment of her position, would be beyond her reach."

From the extrusion of the eggs, which may number in a large Octopus from 40,000 to 50,000, to the escape of the young, a period of fifty days is covered. On emerging from the egg the baby Octopus is about the size of a large flea, and the arms are quite short outgrowths from the head. The little creature rises to the warmer and sunlit surface waters, where it swims about actively for a while, before adopting the more or less sedentary, light-avoiding habits of the adult at the bottom of the sea. Thou-

Octopus Vulgaris

Octopus (Eledon) attacking a Crab

Sepia elegans stranded



Sepiola atlantica

sands of these baby Octopods perish, being greedily devoured by many fishes, and this high rate of infantile mortality is probably the reason of the great fecundity of the Octopus, Nature by this means maintaining an even balance.

The Cuttlefish—the Kraken of the old travellers and naturalists—differs from its cousin the Octopus both in appearance and mode of life. While the Octopus leads a somewhat hermit-like existence at the bottom of the sea, the Cuttlefish loves a roving life in the surface waters, often appearing in shoals near the coast and far out at sea. Cuttlefish vary greatly in size, some species never exceeding a couple of inches in length, others attaining the gigantic proportions of upwards of 60 feet. The body may be long, tapering, and cylindrical, or more or less oval. The eight arms round the mouth of the Cuttlefish are much shorter than those of the Octopus, but from within the circle rise two very long additional arms, sometimes thrice the length of the animal, which terminate in a club-shaped expansion covered with suckers. The Cuttlefish employs these for grasping its prey when beyond the reach of the eight shorter arms, and as anchors to moor itself to drifting seaweeds. The two long arms are destitute of suckers except at their terminal expansions, which are covered with them; and the suckers are even more formidable than those of the Octopus, as they are bordered by a horny ring, having a finely serrated edge, and are mounted on short stalks. In some species the serrated edge is developed into a series of sharp-pointed, incurved teeth, which must sink into the flesh of any unfortunate fish that may be captured, and render its escape absolutely impossible. The Cuttlefish has jaws similar to those of the Octopus, though not quite so large in proportion; it has an ink-bag, very beautiful internal plume-like gills or branchiæ, and embedded in the mantle on the upper surface of the body is the large oblong oval, limy internal shell, familiarly known under the name of "cuttle-bone."

The Pearly Nautilus (*Nautilus pompilus*) is an inhabitant of the Indo-Pacific Ocean, and is the only living representative of the four-gilled Cephalopods or **Tetrabranchiata.** Its large and beautiful shell is a familiar object in museums, and has an outer porcelain-like layer beneath which is the beautiful and harder nacreous or mother-of-pearl layer. The animal differs from all the other living Cephalopods not only in the possession of four gills, but also in having

a number of small retractile feelers in place of the powerful, sucker-clad arms. A vertical section through the shell shows that it is divided into a series of chambers connected to each other by a slender tube or siphon, the exact function of which is still doubtful. The partitions across the shell represent periods of growth: the Nautilus, as it outgrows the capacity of the outer chamber in which it lives, forms a new one of larger size, and separates it from the old chamber by a transverse partition.

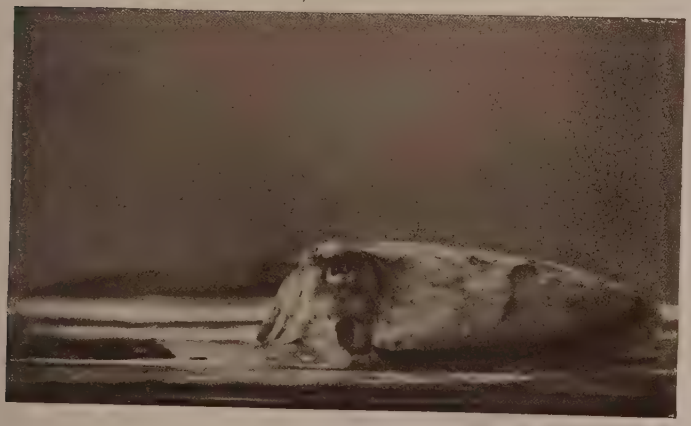
The order **Gastropoda** is a very extensive one, and includes a vast number of species inhabiting the sea, fresh water, and the land; while many occupy a transitory position between salt and fresh water and water and land, and are found in salt marshes in brackish water, in swamps and mud-flats, on the margins of the sea, rivers, and lakes, and high up on rocks where they are only occasionally covered by the tide or moistened by the spray.

The Gastropod Molluscs are distinguished by the broad, flat foot which occupies the whole of the under surface of the body. On this strange foot the animal creeps or glides along, with a slow, rhythmical movement, by the expansion and contraction of strong muscles. If a Periwinkle is watched as it moves over the side of a glass tank, or a snail as it crawls on a window-pane, the muscular movements of the foot may be seen following one another in rapid, wave-like succession.

The animals possess a more or less distinct head, a jaw or a pair of jaws, and a ribbon-like tongue covered with rows of minute teeth called the *radula*, *lingual ribbon*, or *odontophore*. The length and breadth of the radula varies considerably in different genera; in the air-breathing Molluscs it is very broad and rather short, but in the *Littorina*, dwellers in the littoral zone between high- and low-water mark, it is very long and narrow, and when not in use is kept coiled up like a watch-spring at the back of the animal's throat.

The teeth on the radula vary greatly in form and number. The carnivorous Molluscs have, as a rule, comparatively few teeth, which are large and powerful, usually hooked, sickle-shaped, or barbed like arrow-heads, and sometimes provided with poison glands. Vegetable feeders, on the other hand, have, normally, quantities of minute teeth which may be long and slender or blunt and rounded. The tongue of the Limpet is often longer

Cuttlefish swimming



Cuttlefish resting

Limnæ Stagnalis and two shells of *Planorbis*

Univalves, showing right- and left-handed spirals

than the shell itself, and is armed with as many as 1,920 tiny hooked teeth arranged in 160 rows of twelve teeth each. The Whelk has from 220 to 250 teeth, the common Periwinkle about 3,500, the Garden Snail (*Helix aspersa*) owns about 15,000 teeth, and a large Mexican Snail (*Helix Ghiesbreghti*) is the proud possessor of 40,000. But even this extraordinary number is beaten by the curious Umbrella Shells, some species of which boast more teeth than it is possible to count, though the number is roughly calculated to be somewhere about 750,000.

This curious tongue is used by the Mollusc to rasp and tear the food, which is first bitten off by the horny jaws, the morsels of food as they pass along the tongue to the gullet being rasped and torn by the sharp, prickly teeth as they are forced onwards by the worm-like movements of the radula. From this constant rasping action the front rows of teeth often become worn away, and their place is taken by the next rows in order which are successively pushed up from behind.

The head of a Gastropod Mollusc bears from two to six tentacles arranged in pairs, one of which usually carries a pair of eyes, placed either at the tip, as in the land Snails, or at the base, as in the majority of marine species. In some cases, however, the eyes are not carried on the tentacles, but are placed farther back at the sides of the animal's neck. In some species the eyes are altogether absent, while in others—Natica, Sigaretus, and Doris—although the eyes are developed, they are covered with a thick skin, rendering the animal practically blind. The eye in the Gastropoda varies considerably and is more or less well developed in different species. Thus, in the Limpets (*Patella*) the eye is a mere depression lined with pigmented and retinal cells ; in Trochus the eye is more advanced, the depression is deeper and filled with a bright crystalline mass ; while the great Wing Shells (*Strombidæ*) of the tropic seas possess well-developed eyes with a distinct pupil and a double iris, which is often wonderfully coloured, and said to equal the eyes of birds and reptiles in beauty and correctness of outline.

Far the greater number of Gastropods are protected by an external univalve shell, a few species have an internal shell, while in others the shell is rudimentary or altogether absent, or it may be partly external and partly internal. The Chitons differ from

other Gastropods in being clad in a suit of mail consisting of eight shelly plates which overlap, enabling the molluscs, when alarmed, to roll themselves up in the same way as a woodlouse or armadillo bug. Univalve shells vary remarkably in form, size, and colour, ranging in almost countless modification and variation from the simple tent-shaped shell of the Rock Limpet to the wonderfully sculptured and twisted Wing Shells and Harp Shells of the Tropic seas, and include some of the most beautiful specimens of Nature's handiwork.

The most common form of univalve is a more or less elongated cone, coiled round and round on an axis, varying from the long, tapering Turret Shells (*Terebra*), which have twenty or more whorls, to the wide, flattened Ear Shells (*Haliotes*), which consist practically of an abnormally large body whorl. The majority of spiral shells are dextral, or right-handed, but cases of sinistral or left-handed shells are not remarkably uncommon. These "reversed" shells, as they are called, may occur as monstrosities among species which are normally dextral, or the particular genus or species may be normally sinistral; while in some cases the shells may be indifferently either one or the other.

Gastropod Molluscs, with a few exceptions, are unsymmetrical, the body being coiled up in a spiral within the shell, and the breathing organs are developed only on the right side, except, of course, in sinistral shells, when the reverse is the case.

Shells are composed of pure carbonate of lime, a very small proportion of phosphate of lime, and an organic base called *conchiolin*—a substance allied to chitin. They are formed by the mantle, the fleshy cloak which envelops the little mollusc. The shelly matter is deposited in layers by the *margin* of the mantle, for although the whole of the mantle is provided with shell-depositing glands, which are used to thicken the inner layers of the shell and to repair any damage it may sustain, such as a fracture or a small hole, the margin alone enlarges the shell, and contains the pigment cells which give the shells their varied and delicate tints.

Many univalve shells are provided with a thin, flat plate, called the *operculum*, which partly or entirely closes the aperture when the animal is retracted. The operculum is carried on the dorsal side of the foot, so that in crawling it does not impede

the progress of the mollusc. The plate is usually of a horny substance, but may be stony or shelly; many are very beautiful objects, and are sometimes fashioned into trinkets.

The Gastropoda are divided into four classes. 1. The **Prosobranchiata** includes all the univalve shells which breathe by means of pectinated or plume-like gills contained in a vaulted chamber, formed by the mantle, at the back of the animal's head, *in front of the heart.*

2. The **Amphineura** are symmetrical Molluscs. The shell is never spiral, but, when present, is composed of eight plates which overlap one another like tiles on the roof of a house. The gills are arranged in pairs, and are similar on both sides of the body. This class includes the Chitons and certain worm-like Molluscs which have no shell, but have the upper surface of the body studded with minute spicules or spines.

3. The **Opisthobranchiata,** often called Sea-slugs, have usually no shell; when present it is either small or rudimentary and more or less concealed by the mantle. The gills are placed *behind the heart.*

4. The **Pulmonata.** Air-breathing Molluscs provided with a lung-cavity in place of the ordinary gill. To this class belong the Land Snails and Slugs and the Fresh-water Snails.

Far the greater number of the marine Gastropods are dwellers in the littoral zone or the shallow waters just beyond, and with the exception of the extreme Arctic and Antarctic regions there is hardly a part of the coast all over the world where some of these strange and interesting creatures are not to be found. The warmer parts of the globe are richest in number and variety of species and in the large size and brilliant colouring of the shells. The beautifully marked and tinted Cones, Olives, and Volutes, beloved of shell collectors, the brilliant Orange and Tiger Cowries, the huge Wing and Fountain Shells, the Helmet Shells, Mitras Shells, and the curious Scorpion Shells are all dwellers in tropical or sub-tropical seas.

The Wing Shells (*Strombidæ*) are the largest Gastropods possessing a snout, or proboscis, which is non-retractile. These molluscs do not crawl with the usually slow, gliding movement, but progress through the shallow water by a series of curious jerks. They are very active and great scavengers, feeding on dead fish and

other decomposing animal matter; and to see these huge shells moving about amongst the coral reefs by a succession of little leaps and bounds as they search for food is a most curious sight. The Fountain Shell of the West Indies, which belongs to this family, sometimes weighs as much as five pounds, and is nearly a foot in width. As it becomes old the mollusc fills up the apex and spines of its shell with solid shelly matter.

The largest British univalve is the Whelk, some species of which, found on the coast of Scotland, attain a length of from six to seven inches. All the Whelks are carnivorous in their habits, and are most voracious creatures, much dreaded for their depredations in oyster beds. *Purpura lapillus*, commonly called the Dog Whelk, is perhaps the worst offender; but *Buccinum undatum*, the Common Whelk, and *Nassa reticulata*, also sometimes called the Dog Whelk, and one or two other species, are all accredited with being partial to an oyster lunch. The Whelk first fixes itself firmly by means of its great foot on the shell of its victim, and then proceeds to drill a neat hole in it with the file-like end of its radula. Through this hole the mollusc inserts its long, flexible proboscis, and actually sucks the oyster out of its shell. The Whelk family by no means confine themselves to oysters, but devour limpets, periwinkles, top-shells, mussels and other bivalves, in the same manner, or they will eat any dead animal matter that comes in their way.

Purpura is one of the commonest Gastropods of the seashore. Quantities may be seen clustered together on nearly every breakwater when the tide is out. The shell is exceedingly variable in colour, ranging from pure white through deepening shades of yellow and brown to chocolate or even black; while many are banded with contrasting shades of brown, grey, or bright orange.

The Sea Snail (*Natica*), common on sandy shores, is also of cannibalistic habits. The thick, round, smooth shell, tinged with pink and splashed with brown, of this little mollusc is known to most visitors to the seaside. The Natica is quite blind, and lives partly or completely buried in the sand down by low-water mark. The foot is most remarkably developed, and when protruded swells out to such an extent all round that the shell all but disappears within its folds, and it seems almost impossible that the great, fleshy mass can ever return whence it came.

Studies of the Whelk expanding its foot

The Ormer (inner surface of shell)

A chain of Slipper Limpets

With this huge foot the Natica slowly ploughs its way along in the soft sand, making a regular furrow as it goes, in search of the small bivalves that lie buried beneath the surface. With its file-like tongue it bores a hole right through their shells and greedily sucks out the contents.

The Top-Shells, the Periwinkles, and the Limpets are all vegetable feeders, and use their long, toothed radula for rasping away at the seaweeds which constitute their food. Many species of Top-Shell (*Trochus*) are found in the low rock pools, in crevices at the base of rocks in shallow water, and amongst the sea-grasses on muddy shores. The shells are pyramidal in shape, with an almost flat base, those frequenting deeper water always being much more depressed than those found between tide marks. The genus *Trochus* has a very wide distribution; the shells are often beautifully coloured and sculptured, the finest specimens being found in the tropic seas.

The Limpets, which are such familiar objects on the rocks between tide marks, have no operculum; the great round foot occupies the whole of the opening of the tent-like shell. With this the animal adheres to its support so firmly that it is said[1] that a limpet with a base of an inch and a quarter by one inch requires a pull of seventy pounds to dislodge it. Limpets are nocturnal in their habits, like the majority of molluscs, and leave their positions only at night-time to feed; but they always return again to exactly the same spot, so that in time the surface of even the hardest rock becomes worn away by the mollusc, and a shallow pit is formed into which the edge of the shell exactly fits. The shell of the Rock Limpet is remarkably hard and solid, as it has to bear the full force of the breaking waves; while other species of limpet that habitually float in the water attached to the stems of seaweeds are considerably thinner and much smoother in texture.

There are many limpet-like shells called "False Limpets," for although the shells are practically identical with the shells of the True Limpets (*Patella*), the animals themselves differ in the arrangement of the gills. True Limpets have a circle of well-developed gills round the sides of the foot, on the edge of the mantle. False Limpets have only a small gill placed on the left side of the neck.

[1] J. Sinel.

The Keyhole Limpets and the Split Limpets have limpet-like shells, but the first are distinguished by a small hole at or near the apex, and the second by a slit of varying length in the margin of the shell. Through these apertures the water escapes after it has bathed and aerated the gills below.

The Ormer or Ear Shell (*Haliotis*) has a series of perforations on the margin of the shell through which the water passes, and the mollusc protrudes delicate filaments that wave about in the water and so keep up a constant circulation. The Ormer clings to the rocks with its great foot as tenaciously as a limpet, and is just as dull-looking in outward appearance; but the shells have a most beautiful lining of mother-of-pearl, which is much used for inlaid work and the manufacture of ornaments. The Ormer is found in most parts of the world, with the exception of South America, but the only British species occurs in the Channel Isles, where it is fairly common on stones and rocks in low rock pools.

The American Slipper or Chain Limpet (*Crepidula fornicata*) is one of the most curious of the limpet-form shells. Its remarkable life-history has been described by Mr. J. H. Orton, B.Sc., as follows:—"Crepidula spawn during the period from early March to the beginning of November, but the greater number of individuals appear to spawn about May. This limpet takes special care of its spawn. It constructs about fifty to sixty membranous bags, into each of which it passes about 250 eggs, and as the bags are made and filled with eggs they are closed and fastened together by short cords. These cords are finally all stuck on to the surface on which the Slipper Limpet happens to be sitting, so that by taking away the spawning individual the spawn is uncovered; it looks like a bundle of balloons, each containing a number of eggs.

"The eggs are protected by the mother Crepidula for almost a month, but about the end of the month holes appear in the egg-bags, and the developing Crepidulæ escape by swimming away from their parent.

"After a short free-swimming period, the young limpets settle down on some convenient shell, and there they remain for the rest of their lives. They habitually attach themselves to one another, so that regular chains of Slipper Limpets, each one fixed

to the back of another, are formed, the chain often consisting of twelve or more individuals.

"Crepidula is a protandric hermaphrodite—that is to say, all the individuals are born as males, and, passing through an apparently hermaphrodite stage, change into females. Consequently chains are formed in the following manner:—

"The young male individuals creep about from place to place, and eventually settle down either on a shell or some similar surface, or at the end of a chain. Suppose an individual to settle on an oyster shell. The young male grows larger, and at the time the edge of its shell takes on the contour of the surface to which it is attached, so that they fit accurately together. As the individual increases in age, it begins to change into a female, another young male in the meantime having crept on to its back. With a repetition of this process, longer and longer chains are formed, until in odd cases as many as thirteen individuals may be found in chain. In this way it will be seen that in any chain the bottom individuals will be females and the end individuals males, while between these may occur individuals of all intermediate sex forms between male and female." [1]

The Slipper Limpet made its appearance in England in about 1880, probably being introduced with imported American oysters, on which it is fond of fixing itself, and in some places the Crepidulæ have multiplied to such an extent that they have become a troublesome pest to oyster fisheries.

The Cowries are an interesting family of carnivorous Gastropods, for the most part inhabiting the tropic seas. They are distinguished by the varied markings and wonderful polish of the shells, the enamelled surface being produced by the action of two flaps of the mantle, one on either side, which turn back over the shell and meet together in the centre.

The animal inhabiting the shell is most brilliantly coloured; it has no operculum, and its foot is so large that it appears remarkable that it can so easily be protruded and withdrawn through the narrow, slit-like aperture which distinguishes the Cowry shell. Cowry shells are used as ornaments by many savage tribes, and the large Orange Cowry is worn as a mark of high rank by the

[1] J. H. Orton, B.Sc., Journal of the Marine Biological Association. Vol. ix., No. 3, p. 437.

chiefs of the Friendly Islands. Only one specimen (*Cypræa europæa*) is found on the British coast. It is a pretty little ridged shell, banded alternately with white and purple or white and flesh colour, and is often further adorned with three dark brown spots.

The Umbrella-Shell (*Umbrella mediterranea*), the Sea-hare (*Aplysia*), and the Sea-lemon (*Doris*) are typical examples of the third order of Gastropods; to which also belong the Sea-bubbles (*Bullidæ*) that flit about in shallow pools on muddy shores, and the Sea-butterflies (*Pteropoda*) that swim freely in the open sea by means of a curious pair of side fins developed from the neck or mouth. As the little molluscs swim about, these fins flutter like butterflies' wings, and from this they have gained their popular name.

The quaint Umbrella-Shell is somewhat slug-like in appearance, and bears upon its back a small, round, flat shell which has a striking resemblance to a miniature Chinese umbrella, and is quite inadequate as a protective covering to the little animal, though it acts as a shield to its delicate breathing organs, which are situated beneath it.

The Sea-hare, or Sea-slug, has gained its first popular name from the upper pair of tentacles, which stand erect upon its head like the ears of a hare. This mollusc bears upon its back a thin, curved, horny shell, but it is very small and almost hidden by the folds of the mantle. The Sea-hare is found in most parts of the world, frequenting rock pools down by low-water mark, and in the shallow waters off the coast. When disturbed it ejects a quantity of purple fluid which at one time was believed to be highly poisonous; and the harmless little mollusc was regarded with superstitious awe by fishermen in most parts of the world.

The Doris or Sea-lemon belongs to the **Nudibranchs** or Naked-gilled Molluscs. It has no shell, and carries its plume-like gills arranged in a rosette at the posterior end of its body. The Doris looks very much like a lemon cut in half lengthwise, and is usually some shade of dull yellow, though different species vary very much in colour, some being pure white. Some Nudibranchs have no special breathing organs, and respiration is carried on most probably through the skin. Others breathe by means of feathery or leaf-like gills, carried in tufts upon the back, and these are often extremely beautiful in form and colour.

These curious Naked-gilled Molluscs are very numerous; over a hundred species exist on the British coasts alone, but they are mostly very minute, and often so transparent that they are not readily seen. As a rule, these creatures are carnivorous, feeding chiefly on other molluscs or sea-anemones, while Doris has a strange liking for sponges.

In the Air-breathing Molluscs (**Pulmonata**) the gill is replaced by a lung—or, more correctly, a *lung-cavity*, for the lung of the mollusc is not identical with the lung of a vertebrate animal, but consists of a pouch or cavity, lined with a network of blood-vessels, termed the *pulmonary sac*. Land and fresh-water Molluscs were, in all probability, originally marine forms, which, by a gradual, natural process, have passed through varying stages from water-breathers to air-breathers. Nature, of course, does not stand still, and this process of evolution is still going on to-day; so we find certain forms of Molluscs in an intermediate or transitory state possessing branchial gills, in a more or less evanescent condition, in addition to the pulmonary sac. One group of air-breathers live principally in salt or brackish water; and in the tropics huge species of these Molluscs are found living among the mangrove roots at the mouths of rivers, while others frequent damp woods close by the sea.

Fresh-water Pulmonata, although living in water, are not furnished with gills, and as a rule rise periodically to the surface to take in a fresh supply of air. Nevertheless, many Water Snails seem perfectly able to sustain life under water without rising for quite long periods, and it is probable that in such cases the mollusc respires through the skin, as do some of the Nudibranchs; but opinion is divided upon this subject.

Land Snails have a well-developed shell, into which they are able entirely to withdraw. In the Slugs the shell is usually rudimentary or altogether absent; it may be external or internal, in some species taking the form of a small, shield-like plate covering the breathing organs.

All terrestrial Molluscs hibernate at some period of the year. In hot countries they retire in the dry season, coming out again with the first rain. In cold countries they hibernate during the winter months, seeking before their long sleep some secluded spot —under heaps of leaves or moss, beneath stones, in cracks in old

walls, etc. Slugs usually excavate a chamber in the earth into which they retire alone, curling themselves up almost into a ball and encrusting themselves with their own slime.

Snails are of a more sociable disposition, and several may often be found clinging together in a mass during their winter sleep. In extreme cold weather, or in periods of drought, fresh-water snails bury themselves deeply in the mud, but do not appear actually to hibernate, for even when the ponds are covered with a coating of ice some species have been noticed creeping about below.

With the exception of a single family the Pulmonata have no operculum, but before hibernation, or shorter periods of rest, most land snails form a temporary lid to the opening of the shell, called the *epiphragm*. This covering varies in thickness and composition in different species. It may be quite hard and thick, and contain a considerable quantity of lime; or a simple, thin layer of hardened mucus.

Many land and fresh-water molluscs are capable of enduring extreme cold and heat. They live for several years, and are very tenacious of life, being able to survive treatment that would prove fatal to most creatures. The story of the snails that lived for four years gummed to a tablet in the British Museum is well known, but is so curious that it is worthy of repetition:—

"On the 25th March, 1846, two specimens of *Helix desertorum*, collected by Charles Lamb, Esq., in Egypt some time previously, were fixed upon tablets and placed in the collection among the other mollusca of the museum. There they remained, fast gummed to the tablet. About the 15th March, 1850, having occasion to examine some shells in the same case, Mr. Baird noticed a recently formed epiphragm over the mouth of one of these snails. On removing the snails from the tablet and placing them in tepid water, one of them came out of its shell, and the next day ate some cabbage leaf. A month or two afterwards it began repairing the lip of its shell, which was broken when it was first affixed to the tablet."[1]

Several other instances are on record of snails reviving after having been kept shut up in boxes and bottles or fastened to cards

[1] Ann. Mag. Nat. Hist. (2) vi. (1885), p. 68.

for several years, one of the most extraordinary being related by Gaskoin :—

"Specimens of *H. lactea* were purchased from a dealer in whose drawer they had been for two years. This dealer had them from a merchant at Mogador, who had kept them for more than that time under similar conditions. One of these specimens, on being immersed in water, revived, and in April, 1849, was placed quite alone under a bell jar with earth and food. In the end of the following October, about thirty young *H. lactea* were found crawling on the glass." [1]

Slugs and snails are only too well known to gardeners on account of the wholesale way they destroy the foliage of plants, and their particular fondness for tender young shoots makes these molluscs one of the most troublesome of pests. But snails and slugs are by no means always strict vegetarians; many species are carnivorous to a greater or lesser extent. The Great Black Slug (*Arion ater*) will devour living earth-worms or feed upon dead animal matter of any sort that comes in its way. In captivity it will enjoy a meal of raw beef, and when neither animal nor vegetable food is to be had, this extraordinary slug has been known to devour newspapers, sand, and even soap. Both slugs and snails are often guilty of cannibalism; and if several are shut up together it is no uncommon thing for them to fall upon and devour each other. A large European snail (*Stenogyra decollata*), when shut up with other species, is said to devour them *shell and all;* while some of the larger slugs, when handled, will sometimes bite and rasp their captor's hand.

Snails and slugs possess the "homing" instinct in a very marked degree, and after their nocturnal excursions in search of food will return with great regularity to the same hiding-place. If ejected from their home and flung to a distance of several yards the molluscs will almost invariably be found again in the same position as before, when sufficient time has elapsed to enable them to creep home. They are said, too, to show signs of marked intelligence. Darwin gives an interesting account [2] of a couple of *Helix pomatia*, one of which was sickly, placed in a small, ill-provided garden. The stronger of the two disappeared over the wall into the next garden, which was well furnished with food.

[1] Ann. Mag. Nat. Hist. (2) ix., p. 498. [2] "Descent of Man," i., p. 325, 1st edit.

It was concluded that the snail had deserted its weakly mate, but after twenty-four hours it returned, and apparently communicated the results of its expedition, for in a short time both started off along the same track and disappeared over the wall.

The muscular strength possessed by snails is really remarkable. A naturalist carried out some experiments on a Snail (*Helix aspersa*) weighing ¼ oz. He found "it could drag vertically a weight of 2¼ oz., or nine times its own weight. Another Snail, weighing ⅓ oz., was able to drag in a horizontal direction, along a smooth table, twelve reels of cotton, a pair of scissors, a screw-driver, a key, and a knife, weighing in all no less than 17 oz., or more than fifty times its own weight." [1]

Snails and slugs have the power, in common with many other molluscs, of reproducing lost parts. The loss of a tentacle or part of the foot is no very serious matter to these strange creatures, for in a short time it will have grown again. During hibernation no new growth takes place; and if a snail meets with an injury just before its dormant period, this will remain in the same state until the animal returns to activity, when the healing process will at once commence.

True Snails (*Helicidæ*) are found in nearly every part of the world, and in almost every kind of situation, from the sea-level to an altitude of 12,000 feet. Many are remarkable for the beautiful colouring of their shells. The Giant Snail (*Achatina fulva*) of East Africa is over 8 inches in length from the tip of its horns to the apex of the shell, and its eggs are as large and as hard as pigeon's eggs. Other species, quite as large, are found in South America.

The **Scaphopoda** differ from other molluscs in having a long, tubular shell, open at both ends, very much like the shelly tubes formed by certain species of marine worms. To this order belong the Tooth or Tusk Shells (*Dentaliidæ*), of which two species are found in Great Britain. These molluscs have no eyes, no tentacles, and no distinct head, no heart and no gills; and respiration is carried on by the walls of the mantle. They have a long, narrow foot; with this they burrow in the sand in which they live and find their food. This consists of foraminifera and minute bivalves, for although the Tooth Shells have no head they possess a mouth,

[1] Sandford, *Zoologist*, 1886, p. 491.

somewhere near the centre of the body, and on each side of the mouth is a curious bunch of filaments, apparently used by the molluscs for seizing their food; they have, too, a large radula to enable them to rasp it.

In the order **Pelecypoda**, popularly called "bivalves," the mollusc is enclosed in a shell which consists of two plates or valves. The valves are connected by an elastic ligament and articulated by interlocking teeth which form a perfect hinge. During the life of the animal the valves are closed by one or two large muscles, termed the *adductor muscles*. After death, when the muscles cease to act, the valves gape open in consequence of the pull of the elastic ligament. If we examine an empty bivalve shell we shall see one or two large circular scars on the inner surface, which are the points of attachment of the adductor muscles. We shall also notice within the margin of the shell a single, unbroken line; this is called the *pallial line*, and marks the line of attachment of the mantle of the mollusc to the interior of the shell.

Bivalve Molluscs differ considerably from univalves; they have neither head, jaws, nor tongue (with a few exceptions). The body of the animal lies within the valves of the shell between two folds, or lobes, of the mantle which lines the interior of the shell. The gills are leaf-like and disposed on each side of the body, and the mouth is a simple opening at the anterior end, usually between a pair of thin, fleshy lips or *labial palps*, through which the food is conveyed. In some bivalves the edges of the mantle are quite free, and when the valves are open the water readily flows within the shell, carrying fresh supplies of oxygen to the gills, and food to nourish the mollusc. The edges of the mantle may be either simple, folded, or fringed with tentacles or cilia. In others the mantle lobes are joined at one or more points, forming separate openings for the in-flowing and out-flowing currents of water, and for the passage of the foot, when this is present. The apertures for the ingress and egress of the water may be simple openings in the mantle, but in the majority of the Mollusca the orifices are drawn out into long tubes or siphons through which the water circulates. The siphons may be entirely free throughout their length or partly fused together.

Bivalves are sedentary creatures, and do not roam about in search of food as do the Gastropods. Many species, after their

short free-swimming period is over, settle down on some suitable spot, and remain there for the rest of their lives, existing on the minute particles of animal and vegetable matter carried to their mouths by the water which flows between the open valves of the shell. Others are able to swim through the water by rapidly opening and shutting their shells; and some possess a well-developed foot by which they can move from place to place, burrow in sand, or even, in some species, in wood or hard rock.

The Oyster is typical of the molluscs that lead an entirely sedentary life. It has no foot, the edges of the mantle are free, and bordered by a short fringe. The valves of the shell are unequal, the animal lying in the deeper of the two, on which the flat valve closes down like the lid of a box.

The sexes in the British Oyster are not separate, each individual functioning as both male and female at different periods. Whether the oyster fecundates its own eggs is still a vexed question, some authorities holding that the oyster is first male and then female, the spermatozoa being set free before the eggs are produced; others, that the individual is first female and then male, in which case the oyster fertilises its own ova.

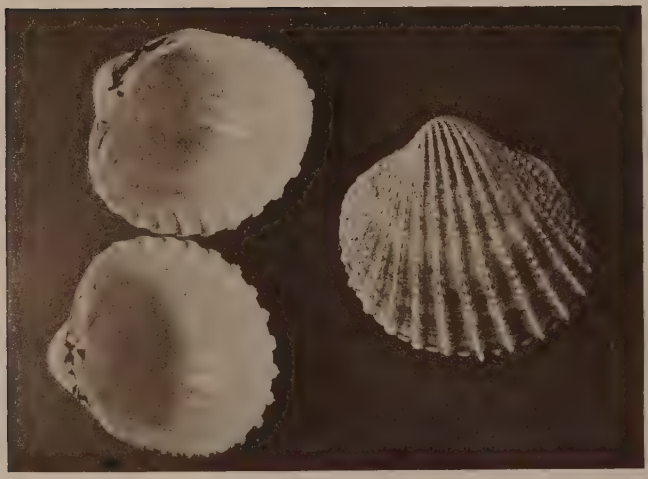
The eggs are retained within the parent shell until they are hatched, and then expelled in clouds which look like puffs of smoke in the water. Warm weather is absolutely necessary for the safety of the "spat," as these young oysters are called, and the spawning season lasts from about April to May. Each young oyster is enclosed in a tiny transparent shell and provided with a fringe of cilia with which it paddles its way through the water. In about forty-eight hours' time the spat *falls* and adheres to the rocks, shells, and stones at the sea bottom, and the young oysters lose their cilia and settle down for life.

The oyster increases in size by adding a fresh layer to the margin of its shell from time to time. The new ring is at first almost as thin and transparent as gold-beater's skin, but in a short time it thickens and hardens into shell. The oyster is not full grown and fit for table until it is five years old; and if it does not share the fate of so many of its fellows in being cut off in its prime, it may live for ten years or more; but after a time it ceases to add new rings to its shell, and simply increases the thickness:

A Starfish forcing open an Oyster

A Whelk boring through the shell of an Oyster

The great Swan Mussel



The Prickly Cockle

The Pectens, or Scallops, in their early days dart through the water by rapidly opening and shutting their valves, but as they grow older they become more sedate and spend most of their time resting on one spot, much as oysters do. The Pecten has a small but distinct foot, which is not used as a means of locomotion, but is employed by some species to spin a small bunch of threads called the *byssus*, or beard, by which the mollusc attaches itself occasionally to its resting-place. The eyes of the Pecten are very remarkable. They number from 80 to 120, and lie in two rows on the borders of the mantle. When the valves of the shell are open these eyes may be seen shining like jewels through the folds of the mantle, which depends like a misty veil from the edges of the shell.

The Limas (*Limidæ*) are very like the pectens, but their shells are always white and the fringe of the mantle is very long and beautifully coloured. These molluscs are more active than the pectens, and dart through the water with quick, jerky movements, flapping the valves of their shells like a pair of wings. The Limas are sometimes called "Sea-butterflies"—a name, by the way, which is given indiscriminately to a great many different sea-creatures. They are remarkable for making a kind of nest with pieces of coral, stones, and shells, bound together with threads spun from the byssus gland, and in this several Limas will live contentedly together.

In the Mussels the byssus gland is very highly developed, and the molluscs habitually anchor themselves by their strong threads to their resting-place. They form huge beds of tens of thousands, connected together by their byssus, and it is a common sight to see great masses of the shells clinging together on the rocks and breakwaters down by low-water mark, with small stones, grains of sand, fragments of shells, etc., all mixed up in the network of threads. The attachment, however, is not entirely permanent, for a mussel will sometimes cast off the byssus and move away to another place.

The Edible Mussel (*Mytilus edulis*) is found near the coast in most parts of the world, from the Arctic to the Antarctic Ocean; it is used very largely as bait as well as food, but is often very unwholesome and even poisonous to many people.

The characteristic foot of a bivalve is axe-shaped; it is often

small and but feebly developed, but in those molluscs which burrow deeply in the sand or mud, or excavate holes in hard substances, it has become exceedingly strong and is often of considerable size. In the Solen, or Razor-shell, the foot is the most remarkable feature of the mollusc; by means of its powerful foot the Solen bores a deep, perpendicular tunnel in the ground, and in this retreat it lives, ascending and descending by the expansion and contraction of its extraordinary and accommodating foot, which can be stretched out to a great length or drawn completely within the shell, while the tip may be pointed to furnish an efficient boring instrument or swelled out into a thick knob to enable the mollusc to wedge itself firmly in its burrow.

The Pholas, or Piddock, bores into rocks, wood, mud, or sand. It is a small mollusc, with a white-ridged shell which is strong, although very thin. Its foot is white and soft, and almost as transparent as ice, but at the tip is a layer of sharp, flint crystals, converting it into a perfect file. With this instrument the Pholas rasps away with such persistence that the hardest substance in time becomes worn away; and as the crystals are worn down with hard work they are replaced by a new set.

The Teredo, or Ship-worm, is another curious boring mollusc. It tunnels chiefly into timber, and does a great deal of damage to piles, breakwaters, etc., which are not protected by metal. The Teredo is a strange-looking creature, with a long, worm-like body enclosed in a thin shelly tube, having a very small bivalve shell attached to the thicker end, which serves to protect the mouth and the internal organs of the animal. Some large species of Ship-worm are quite a foot in length; others not more than 6 inches.

The Cockle has a large, muscular foot, pointed at the tip and bent in the middle. This is used not for burrowing or boring, but for locomotion. By its aid the Cockle progresses over the ground by a series of astonishing leaps and bounds. These molluscs frequent sand-banks on the margin of the sea, and when the water retreats, leaving them uncovered, they bury themselves in the sand. When the sea returns the Cockles emerge and hurry down to meet the incoming tide, hopping and bounding along on their sturdy bent "foot" in the most amusing manner.

The largest of the bivalves are the great Clams (**Tridacnidæ**);

the largest known species (*Tridacna gigas*) sometimes weighs over 500 lb. These huge molluscs are found in the lagoons, among coral reefs. The animals themselves are wonderfully coloured, and gleam with iridescent tints.

The eggs of molluscs vary greatly in number. The Oyster (*Ostrea edulis*) produces from 300,000 to 60,000,000 ; a Common Snail (*Helix aspersa*) from about 40 to 100. The marine Gastropods belonging to carnivorous families deposit their eggs in little leathery cases of different shapes and sizes, each case containing several eggs. The large clusters of eggs formed by the Whelk are well known objects on the seashore, and the delicate cases containing the eggs of Purpura (the Dog Whelk) may be seen in the crevices of rocks or wooden breakwaters, each one about the size of a grain of rice and fashioned like a wine-glass on a slender stem, the colour being a delicate pink.

The curious curled cakes of sand we sometimes find on the seashore contain the eggs of the Natica, while the Doris disposes her eggs in a long, gelatinous ribbon wound round and round into a kind of rosette. Few molluscs take any care of their eggs, but the "Violet Snail" (*Ianthinida*) constructs a gelatinous raft, which is filled with air-bubbles to act as a float ; to the underside it attaches its tiny eggs, and this egg-raft is fastened to the foot of the little mollusc.

CHAPTER VII

THE CRUSTACEA

If we look at a lobster, a scorpion, a centipede, a caterpillar, and a beetle, we shall see that they have in common certain well-marked features. They all possess a hard or tough integument; the body is more or less distinctly divided into segments; the legs, feelers or antennæ, mouth parts, etc., are also divided by joints into a number of segments, and are covered with the same hard or tough coat as the body; while certain characteristic points in the arrangement and structure of the internal organs are common to all. For this reason these animals so diverse in form and habit are included in one comprehensive group or phylum, called the **Arthropoda,** and divided into four great classes: (1) the *Crustacea*; (2) the *Arachnida* (spiders and scorpions); (3) the *Myriapoda* (centipedes and millipedes); and (4) the *Insecta* (butterflies, moths, beetles, flies, etc.).

The class **Crustacea** comprises the Lobsters, Crabs, Crayfish, Shrimps, Prawns, Sandhoppers, Water-fleas, Barnacles, and Wood-lice, besides a host of chiefly small related forms that have no popular names, and are practically only familiar to the specialist. The class contains a vast assemblage of animals most diverse in size and appearance, and mostly aquatic in their habits. They are an interesting group of animals, and many of them pass through a remarkable series of transformations or metamorphoses ere reaching the adult stage.

If a Shrimp or a Lobster be examined, it will readily be noticed that its hard body-covering or integument is made up of a number of segments jointed together, to which are united by jointed sockets the claws, legs, and long feelers or antennæ. To give greater protection to the soft parts of the body, a number of these segments are soldered together so as to form one piece; but these fused body-rings can always be detected, for normally each seg-

ment has one pair of jointed limbs, and therefore a segment having more than one pair of limbs attached to it may be regarded as composed of several segments fused together. In this segmentation of the body the Crustacea fall naturally into three categories: (1) the *Entomostraca*, in which the number of segments is indefinite; (2) the *Malacostraca*, in which may be counted nineteen segments, exclusive of the terminal piece or telson and omitting the lateral eyes; and (3) the *Leptostraca*, including the single recent genus *Nebalia*, in the abdomen of which two additional segments occur. The Malacostraca includes the Crabs, Lobsters, Prawns, Hermit Crabs, Sandhoppers, Woodlice, and their allies; while the Entomostraca comprises a vast assemblage of small Crustacea in which the eyes are rarely borne on movable stalks, and of which the so-called "water-fleas" are a familiar example.

In nearly all the Crustacea the young pass through a series of metamorphoses after they quit the egg, and do not at first resemble the final adult stage. Thus the young of the Common Shore Crab (*Carcinus mænas*), on escaping from the egg, does not resemble its parents in the least. It has fixed eyes without eye-stalks, a long body destitute of any appendages; it has no walking legs, but uses its maxillipedes, or jaw-feet, for purposes of locomotion, swimming with a jerky motion through the water. In this, the *zoœa* stage, as it is called, the baby Crab is a most comical-looking little creature, with a great helmet-like head, crowned by a long spine rather like an exaggerated dunce's cap, and a second long spine or nose in front. The little thing swims actively about in the sea, and, casting its skin from time to time, passes through a gradual series of changes until it reaches the *megalopa* stage, in which the eyes have become mounted on stalks, the ten legs have developed, the body has broadened, and the tail shortened. Finally, it gives up the free-swimming life, comes close to the floor of the sea, tucks up its abbreviated tail beneath the body, and assumes the adult form.

A Prawn belonging to the genus *Peneus* undergoes an even more striking series of changes. It quits the egg as a tiny creature with an unsegmented body, a single eye in front, and three pairs of swimming feet; the first pair being simple, while the other two pairs are branched. The mouth is covered by a helmet-like hood. This stage is called the *nauplius*, and after several

moults, in the course of which the little animal undergoes considerable change and development, it becomes a *zoœa*, and is furnished with maxillæ and two pairs of jaw-feet. After a further series of moults the Prawn enters the third stage and passes from the *zoœa* to the *mysis* form, in which the paired eyes, all the appendages of the mouth and head, the segments of the thorax, and the rudiments of the feet appear, and at last the adult stage is reached. Nothing could be more dissimilar in appearance than the nauplius, zoœa, and adult stages in the life of this Prawn.

The process of moulting or skin-casting is not restricted to the early stages alone, but is continued in the adult, the shelly coat being cast off and renewed as often as the growth of the animal renders its enlargement necessary. Crabs and Lobsters, when about to cast their armour, seek out some quiet hiding-place, and cease for a time to feed. Then the old coat of mail is thrown off, the animal emerging from it weak and exhausted by its struggles, but with the new coat ready formed though quite soft. As the animal rests beside its cast-off coat, it looks so much larger that one wonders how it could have been contained therein and certainly it must have felt very uncomfortable. The new coat is at first soft and membranous, but soon becomes encrusted with calcareous matter, and as hard as the old one. The Crustacea also possess the power of reproducing injured or lost limbs. The perfect restoration is not immediately effected, but is gradually accomplished in the course of several moults.

The Crabs are in many respects the most interesting and intelligent members of the Crustacea, and they vary in size from the tiny Pea Crabs, little more than a quarter of an inch in diameter, to the giant Spider Crab of Japan (*Macrocheira Kempferi*), which measures 10 feet between the tips of the clawed fore-limbs. The Spider Crabs are a most interesting group, though not so active in their movements as their long and slender legs might lead one to suppose. Many of these Crabs are quite covered with a living growth of seaweeds, sponges, and hydroids, and, thus disguised, are enabled to stalk their more active prey unobserved, drawing stealthily nearer, until with a sudden dart the victim is pounced upon and firmly grasped by the small, slender claws. The Spider Crabs vary a good deal in length of limb, as can be seen by the photographs of *Macropodia rostratus*, the Long-legged Spider Crab,

The Great or Edible Crab

Male and female Masked Crabs

" Dressed " Spider Crabs

The Spiny Spider Crab

and *Inachus dorsettensis*, the Scorpion Spider Crab. The Common Spiny Spider Crab (*Mai squinado*) attains to 7 inches or 8 inches across the carapace, and is largely used as food on the Continent, and not infrequently in our English fishing ports. The carapace of this Crab is thickly studded with stout spines, and the legs are clothed with short bristles. The females are not so large as the males, and are generally thickly covered with pieces of seaweed. The Four-horned Spider Crab is smaller, and has not so many spines upon its body and legs as the Spiny Spider Crab, but the floating spores of seaweeds readily attach themselves to its body, so that little tufts of weed actually grow upon it. This crab is slow in its movements, and may be found hiding under stones, covered with a dense fringe of wrack-weed, on rocky shores.

The Great Edible Crab and the Common Shore Crab are too familiar to need any detailed description here, but the so-called "Swimming Crabs" or "Fiddlers" are not perhaps quite so well known. These crabs gain their two popular names from their very characteristic movements, a half swimming, half scrambling motion through the water, and the curious shape of the last joint of the hind pair of legs, which is supposed to have a vague resemblance to an ancient viol or fiddle; these legs are worked up and down with great agility when the creature moves through the water. On the coast of France it goes by the name of *Le Crabe enragé*, from its readiness to show fight. The claws are sharp-pointed and well developed. The female carries her great mass of eggs attached to special limbs on the under side of her triangular tail. The Velvet Fiddler Crab (*Portunus puber*) is a very handsome crab, about 4 inches in length, with the knobs and spines on the body and legs marked with dark blue and white, while the carapace is covered with a velvet-like surface of close, fine hairs. Henslow's Swimming Crab (*Polybius Henslowii*) is a truly pelagic or open-sea Crustacean, being found swimming on the surface of the sea at a very considerable distance from the coast.

A most singular-looking crab is the Masked Crab (*Corystes cassivelaunus*), which gains its popular name from the curious grooves or depressions on the oval carapace, that look rather like a queer mask or human face. The sexes differ so much in appearance that they have been described as separate species. When

the tide is out these crabs bury themselves in the sand, only the tips of the long slender antennæ being visible above the surface. The front limbs are enormously long in proportion to the body in the male crab. It is a very ancient type of Crustacea, many fossil forms occurring in the Cretaceous strata.

Of the Land Crabs, the most familiar is probably the Countryman Crab (*Gecarcinus ruricola*), found in Jamaica, Montserrat, and other West Indian islands. At the approach of the spawning season vast armies of these crabs set out from the hills and march across country, regardless of all obstacles, in a direct line to the seashore. Arrived at their destination, the crabs proceed to deposit their eggs in the sand below high-water mark, and this safely accomplished, they start on their toilsome march homewards to their upland retreat. On their way down to the sea they are fat and in fine condition, and large numbers are caught for food ; but on their return journey they are poor and exhausted, and useless for the table. They cause considerable damage in the sugar-cane plantations, some of the species being particularly partial to and almost entirely subsisting upon the sweet juices of the plant.

Land Crabs are very abundant in the Deccan, where they are found at an altitude of nearly 4,000 feet. They do not perform an annual migration to the sea, but probably frequent the margins of the streams. The Calling Crab (*Gelasimus*) of Brazil presents a very curious appearance owing to one of the claws being enormously developed. This limb is used by the crab in digging its burrow in the sand and earth, a task which it performs with astonishing vigour and dispatch. When alarmed, the crab scuttles away towards its burrow in a terrible hurry, brandishing the great claw aloft in a most comical beckoning manner, from which it has gained its popular name.

The **Anomoura,** or Irregular-tailed Crabs, form the connecting link between the Crabs (**Brachyura**) and the Lobsters (**Macroura**), and contain many interesting forms, including the so-called Squat Lobsters (*Galatheidæ*), the little Broad-claw Crabs (*Porcillanidæ*), the Hermit Crabs (*Paguridea*), and the Stone Crabs (*Lithodidæ*). The so-called Squat Lobsters, or Galathea Crabs, are symmetrical crabs with a long carapace, and carry their abdomen tucked under the thorax, in much the same position as is seen

Female Velvet Fiddler Crab, with eggs

Female Velvet Fiddler Crab, with tail drawn down to show processes to which the eggs are attached

Hermit Crab

Hermit Crab removed from Whelk-shell to show soft body

in a boiled Lobster. The claws and limbs are long and slender with the exception of the last pair, which are much reduced in size and are either turned back on to the dorsal surface or carried in the branchial chamber. The pretty little Broad-claw Crabs may be found hiding under stones in the rock pools, frequenting much the same situations as their near relations the Galathea Crabs. They have broad, flat claws, with a fringing of short, stout hairs, and are greyish brown on the upper surface. Indeed, so closely does their coloration harmonise with their surroundings that they readily escape observation. The zoæa stage of these crabs is characterised by the immense length of the spines on the front of the head and at the back, the little creature, as may be seen by the photograph facing p. 116, presenting a very quaint appearance. The Stone Crab (*Lithodes maia*) has a highly calcified shell, and to the casual glance bears a resemblance to a Spiny Spider Crab, but closer inspection discloses anatomical details which unmistakably show its near relationship to the *Paguridæ* or Hermit Crabs, and that its ancestors were probably typical shell-haunting crabs which at some period took to a different mode of life, and so gradually lost those characteristics that are associated with the dwellers in a spiral shell as seen in the Common Hermit Crab.

The Common Hermit Crab is of interest not only on account of its living in a whelk-shell, but also for the curious friendship which exists between it and a sea-anemone that is constantly to be found mounted on the whelk-shell so that it is carried about wherever the Hermit Crab goes. While the anemone benefits in being constantly transported to fresh feeding grounds, and may actually share in the prey captured by the Hermit, the latter probably benefits by being partially screened from view when at rest, when the anemone is fully expanded, and unwelcome visitors may be kept away by the knowledge of the stinging thread cells that clothe the waving tentacles of the anemone.

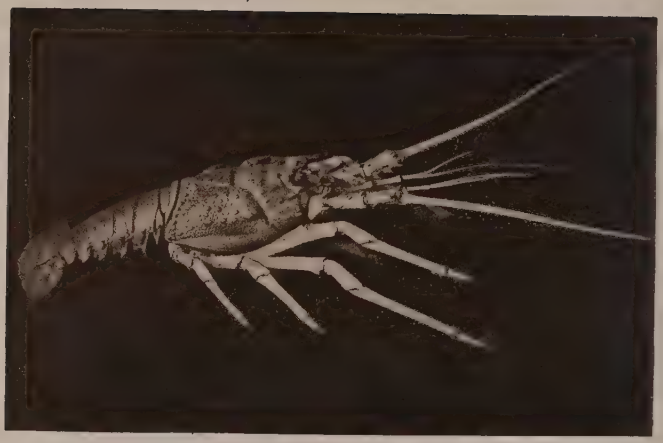
The coral islands of the Indian and Pacific Oceans, where coco-nut trees grow, are frequented by a gigantic crab called the Robber Crab (*Birgus latro*), which often exceeds a foot in length. Darwin gives the following interesting description of it in his account of Keeling Island: "This crab has its front pair of legs terminated by very strong and heavy pincers, and the last pair by others

which are narrow and weak. It would at first be thought quite impossible for a crab to open a strong coco-nut covered with the husk, but Mr. Leisk, one of the two British residents, assures me he has repeatedly seen the operation effected. The crab begins by tearing off the husk, fibre by fibre, and always from the end under which the three eye-holes are situated. When this is completed, the crab commences hammering with its heavy claws on one of these eye-holes till an opening is made; then, turning round its body, by the aid of its posterior pair of narrow pincers it extracts the white albuminous substance. . . . The Birgus is diurnal in its habits, but every night it is said to pay a visit to the sea, no doubt for the purpose of moistening its branchiæ. The young are likewise hatched, and live for some time, on the sea coast. These crabs inhabit deep burrows, which they excavate beneath the roots of the coco-nut trees, and here they accumulate surprising quantities of the picked fibres of the coco-nut husk, on which they rest as on a bed."

The Common Lobster (*Homarus vulgaris*) passes through an interesting metamorphosis. The young Lobster, on emerging from the egg, has no beak or rostrum, and no claws; while the eyes are sessile, not mounted upon stalks as in the adult. The little zoæa moults from time to time, and gradually the jointed thoracic limbs, the claws, long antennæ, and other appendages appear. The adult Lobster is susceptible to what, for want of a clearer expression, I may term hypnotic influence. If a healthy, active Lobster is placed on a table, and the tail held in the left hand while the right hand is lightly swept backwards and forwards from the tip of the beak or rostrum, over the carapace to about the third abdominal segment, the animal soon ceases to move, becomes absolutely helpless, and, as may be seen from the photograph facing page 125, may be stood upon its head, the two claws and the beak forming a tripod support. The Lobster will remain in this position for five to fifteen or twenty minutes, without showing the slightest movement. If returned to the tank it sinks down to the bottom and remains for a minute or two quite rigid and motionless, then a quiver is seen to pass along its body, and in a few seconds the Lobster has come out of its trance. My attention was first drawn to this curious phenomenon by Mr. Elmhirst, the able director of the Millport Marine Biological Station,

The Stone Crab, *Lithoides maia*

Galathea Squamifera, the so-called " Squat Lobster "



A Palanurus, or Crawfish, from Indian Waters

A Baby Spiny Lobster (*Palanurus*)

in Scotland; and though I have carried out several experiments, I have not as yet been able clearly to establish whether the effect produced is truly hypnotic or due to mild frictional electricity. The passing of mild electric currents along the back and carapace has anything but a soothing effect upon the Lobster.

The genus **Palinurus** includes the Common Spiny Lobster (*Palinurus vulgaris*), sometimes called the Crawfish, which inhabits our western coasts. There are no powerful claws, and the true walking legs are all one-toed at their extremity. The illustration facing page 123 is of a Palinurus from India. The Palinuri pass through a complex metamorphosis, the larva presenting a very curious appearance, so different from the adult that, when first observed and described, it was given the name of *Phyllosoma*, or "Glass Crab."

The River Crayfish (*Astacus fluviatilis*), according to the investigations of Ratke, passes through its earlier metamorphosis in the egg. Although it cannot live in salt or brackish water, yet its geographical distribution is wider than that of any other Crustacean; representative species inhabit the rivers of Europe, India, Japan, North and South America, New Zealand, and Australia.

The **Stomapoda**, or mouth-footed Crustacea, show considerable divergence from the crabs and lobsters. Taking *Squilla mantis*, the so-called "Mantis Prawn," as an example, the segments are much less coalesced than in the lobster. Those bearing the eyes and antennules are readily separated from the front of the head, and are not covered by the carapace, which only conceals eight segments, whereas in the lobster it extends over fourteen. The gills are no longer attached to the thoracic appendages and inclosed in a branchial chamber formed by the head-shield, but they are transferred from the thoracic limbs to the abdominal swimming-feet. The first thoracic appendages are developed into a pair of robust claws, the terminal joint being furnished with a row of long and sharp recurved teeth, giving the limbs a great resemblance to those of the curious insect called the mantis.

The **Isopoda** (equal-footed) are sessile-eyed Crustacea, and their name alludes to the general conformity in size and function of the legs. One group of Isopods, the *Oniscidæ*, are familiar to most people under the name of Woodlouse, or Armadillo Bug, the latter name referring to their curious habit of tightly rolling them-

selves up into a ball when alarmed. A gigantic Isopod, measuring 9 inches in length by 4 inches in breadth, far exceeding all other living Isopods in size, and called *Bathynomus giganteus*, was dredged up from a depth of 955 fathoms on the north-east of the bank of Yucatan, and north of Tortugas, by Prof. Alexander Agassiz. The Gribble (*Limnoria terebrans*), so destructive to all woodwork below tide-mark, is also an Isopod.

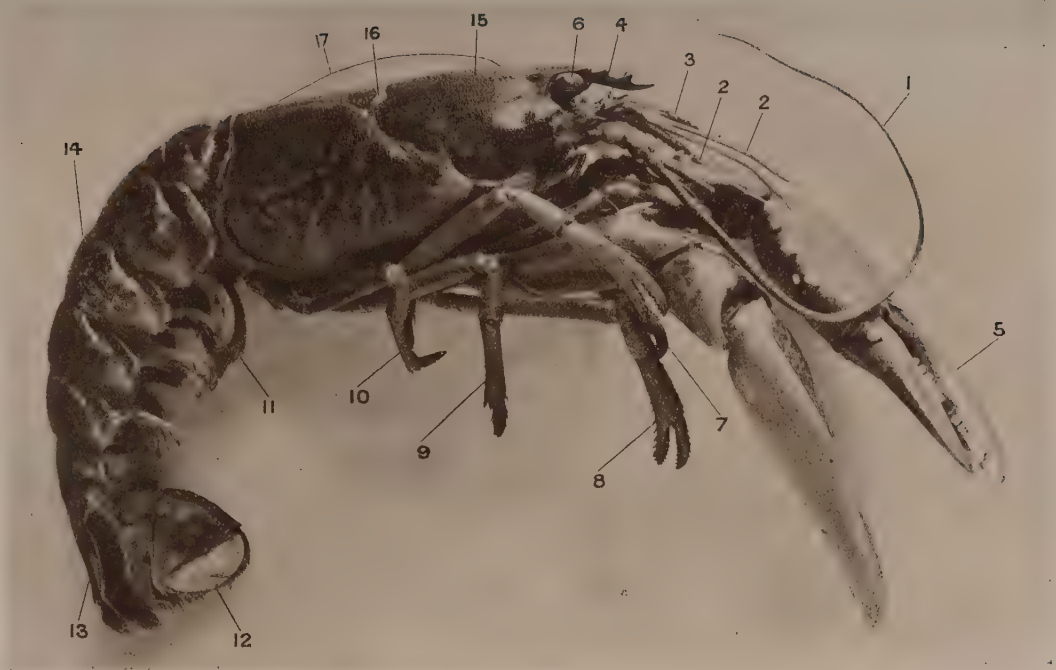
The **Branchiopoda,** or gill-footed Crustacea, are all aquatic, the greater number having a shell composed of two parts or valves, in which they are more or less completely enclosed, or in the form of a buckler, which envelops a large part of the animal. The little *Daphnia pulex*, the so-called Water-flea, is a Branchiopod belonging to the order *Cladocera*.[1]

The **Lophyropoda,** or stiff hair-footed Crustacea, includes the orders *Ostracoda* (Shell-covered) and *Copepoda* (Oar-footed), familiar members of which are the fresh-water Cypris, the fresh-water Cyclops, both inhabitants of ponds; the marine Cetochilus or "Whale-food," which, although quite minute in size, yet swarms in such vast numbers at certain seasons of the year as to colour the sea for a mile or more in extent; and the parasitic Copepod, *Argulus foliaceus*, which is found upon various fresh-water fishes.

The **Cirripedia**[2] includes the interesting Acorn and Stalked Barnacles (the *Balanidæ* and *Lepadidæ*), which pass through a most extraordinary metamorphosis. "Almost everyone," writes Darwin, "who has walked over a rocky shore knows that the Barnacle, or 'acorn-shell,' is an irregular cone, formed generally of six component parts, with an orifice at the top, closed by a neatly-fitted, movable lid, or operculum. Within this shell the animal's body is lodged, and through a slit in the lid it has the power of protruding six pairs of articulated cirri, or legs, and of securing by their means any prey brought by the waters within their reach. The basis is firmly cemented to the surface of attachment. The whole shell, basis, and operculum consists of the first three segments of the head, modified into a singularly constructed carapace, which encloses the mouth and the rest of the body. The anterior extremity of the shell is situated in the centre of the basis, where,

[1] Greek, *klados*, a branch, and *keras*, a horn—branching-horn, in allusion to their antennæ.

[2] Latin, *cirrus*, a curl, and *pes*, a foot—curl-footed.



Lobster

1. Antenna
2. Antennule
3. Third maxilliped
4. Rostrum
5. Cheliped or first leg
6. Eye
7—10 Walking legs
11. Pleopods or swimmerets
12. Uropod } Tail fan
13. Telson }
14. Abdomen somites
15. Carapace
16. Cervical groove
17. Cephalothorax

The Common Lobster

Lobsters under hypnotic condition standing on their heads

Argulus foliaceous, a parasitic crustacean

Pycnogons

Acorn Barnacles

Stalked or Ship Barnacle

Cypris stage of Barnacle

Ship Barnacle cut open to show animal in shell

indeed, by due care, the antennæ of the pupa may be always detected; the posterior extremity is directed vertically upwards.

"The larvæ in the first stage have three pairs of legs, a very simple single eye, and a probosciformed mouth, with which they feed largely, for they increase much in size. In the second stage, answering to the chrysalis stage of butterflies, they have six pairs of beautifully constructed natatory legs, a pair of magnificent compound eyes, and extremely complex antennæ; but they have a closed and imperfect mouth, and cannot feed; their function at this stage is to search by their well-developed organs of sense, and to reach by their active powers of swimming, a proper place on which to become attached and to undergo their final metamorphosis. When this is completed they are fixed for life: their legs are now converted into prehensile organs; they again obtain a well-constructed mouth; but they have no antennæ, and their two eyes are now reconverted into a minute, single, and very simple eye-spot."

The King-Crabs (*Xiphosura*) and the Sea-Spiders (*Pycnogonida*), formerly associated with the Crustacea, are now regarded as more closely related to the Arachnida.

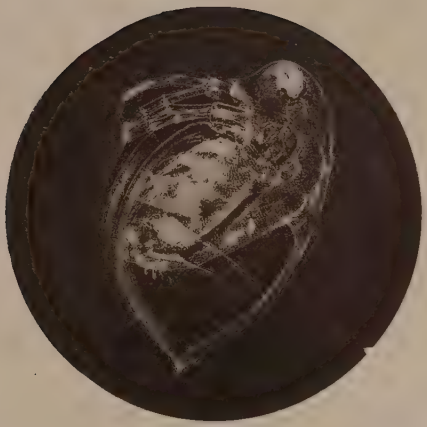
CHAPTER VIII

SCORPIONS, SPIDERS, CENTIPEDES AND MILLIPEDES

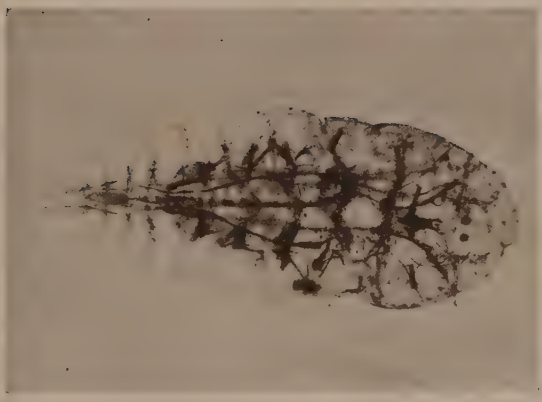
THE class **Arachnida** includes the Scorpions, Spiders and Mites —creatures which breathe by means of "lung-books," tracheæ, or a combination of the two systems of respiration. They have no separate head, the head and thorax being fused together into one division termed the *cephalothorax.*

Scorpions are found in all the warmer parts of the globe. In India and West Africa some species grow to a very large size, and are really formidable-looking creatures, often measuring 9 inches in length. The body of a scorpion is broad and long, ending in a long, jointed tail. The head and shoulders (cephalothorax) are covered by a sort of carapace, reminding one of the carapace of a lobster. Near the centre of the carapace are the two simple eyes, usually surrounded by several groups of smaller eyes numbering from five to two. The front portion of the shield also bears a pair of stout nipping jaws (*cheliceræ*), and a pair of appendages (termed *pedipalps*) armed with strong, crab-like claws. The tail ends in a sting containing a poison gland, and is usually carried curled over the back when the scorpion is taking a walk. When it stings the creature suddenly straightens its tail and strikes *downwards*, so that the old notion that a scorpion surrounded by a ring of fire would deliberately sting itself to death is practically an impossibility. In such circumstances the probability is that the poor creature, unable to escape from the great heat, would become greatly excited and jerk and flourish its tail over its back in its terror; and these movements were believed to indicate that the scorpion was trying to sting itself on the head. Actually,[1] "as poisonous snakes cannot kill themselves or others of their own species by their venom, so scorpions cannot injure by their poison either themselves or other scorpions."

[1] Chambers's Encyclopædia.



The Water Flea (*Daphnia*)



A Copepod (*Sapphirina gegenbauri*)

A Giant Centipede

Scorpion

Scorpions are carnivorous and nocturnal in their habits. They shun strong light and hide by day under stones, in crevices in the rocks, under the bark of fallen trees, or in deep burrows in the ground, which the larger species excavate for themselves with the aid of their pincers. At night they leave their hiding-places and prowl about in search of food, which consists chiefly of insects. Their habit of hiding in all sorts of odd places has made scorpions exceedingly unpopular, for they will frequently enter houses and conceal themselves under pillows, in the beds, or creep into unoccupied boots and shoes. The little black scorpions of Southern Europe are particularly addicted to this troublesome habit, especially during wet weather.

Many people are terribly afraid of scorpions, but the danger of their sting is much exaggerated; and although the wound they give is very painful, it is not, except in the case of the largest species, attended with very serious consequences. The sting of a Great African Scorpion may sometimes cause sickness and a rise of temperature, but it is rarely, if ever, fatal, as is so generally believed. Scorpions, indeed, are really timid creatures, and their chief anxiety is to avoid notice and slink away into some safe retreat.

They are solitary in their habits, each scorpion living alone, except during the mating season, when for a time a pair will dwell amicably together. The celebrated French naturalist, M. Fabre, has given an interesting account of the courtship of these strange creatures, colonies of which he kept in his garden in order to study their ways. He states that after some curious preliminary antics the two scorpions face each other with raised and curling tails, which they intertwine in an affectionate manner. Then they proceed to take what Fabre calls a "*promenade à deux.*" The male clasps the claws of the female with his own, and walks slowly backwards, his mate following him. And thus, hand in hand, the two quaint creatures promenade for an hour or more. When tired of these manœuvres, the male proceeds to dig a hole, generally under a convenient stone, but never for one moment does he release his hold on the scorpion of his choice; and when the marriage chamber is sufficiently large to contain them comfortably, the strange pair disappear from view within it. But the lady scorpion is fickle and bad-tempered, and the chances

are that she soon tires of her domestic life and devours her unfortunate mate.

All scorpions are viviparous, and the newly hatched young ones swarm on to their mother's back, and she carries them about for a week; during this time the young scorpions require no food, they remain motionless, clinging to the female until after their first moult, when they leave the parent and begin hunting for themselves.

Whip Scorpions have no poison glands; the tail is long and thin, like the lash of a whip. They are never of very large size; the largest known species (*Mastigoproctus giganteus*) is found in the southern part of North America, and measures rather more than 2½ inches. These creatures inhabit south-eastern Asia and tropical America, and are found in the crevices of rocks, under stones, beneath fallen tree trunks in damp situations, and some species excavate burrows in loose soil. They feed chiefly upon insects, which they crush with their powerful pincers, and are very unpleasant creatures to handle, for if annoyed or frightened they eject a disagreeable acid fluid from two large glands situated in the last abdominal segment. Some allied forms (*Phrynidæ*) inhabiting warm parts of the Old World, as well as tropical America, have not the long, whip-like tail, and the pedipalps are not armed with the crab-like pincers of the true scorpions. In place of these the animals have a curious movable joint like a curved spine, which can be closed down like the blade of a pocket-knife, and with this weapon they grasp their prey. The carapace of the *Phrynidæ* family is broader than it is long, and distinctly divided from the abdomen. The first pair of legs are extraordinarily long and thin, and used by the animals as feelers.

The Spiders (**Araneæ**) form a very large order of the class Arachnida. The body is distinctly divided into two distinct parts —the cephalothorax, protected by an unsegmented shield or carapace, and a soft, unsegmented abdomen. The eight legs are seven-jointed, and the feet (*tarsi*) are furnished with comb-like claws. The claws are usually three in number, one being much smaller than the two principal claws, which are paired. In many climbing spiders the third claw is replaced by a bunch of stout hairs called a *scopula*. The pedipalpi, which serve as feelers, are six-jointed and leg-like. In the female spider they

usually terminate in a small, hooked claw, and are used as a pair of extra hands for grasping prey or carrying cocoons. In the male spider the pedipalpi end in curious club-like processes which function as sexual organs.

The jaws or falces (*cheliceræ*) are two-jointed, and consist of a base, which sometimes contains the poison gland, and the fang, which is hook-like and can be folded back upon the base like a clasp-knife. Near the tip of the fang is a small orifice leading to the poison gland, through which the poison is ejected into the spider's victim. The poison gland may be situated wholly or partially within the base of the jaw, or may be in the cephalothorax and connected by a narrow duct with the opening in the fang.

Spiders possess from two to eight simple eyes or *ocelli*, the usual number being eight. These are situated in the fore part of the cephalothorax, and usually arranged in two transverse rows. In some species the eyes are mounted on a slightly raised platform, enabling the spider to keep a look out in several directions at the same time. In spite of the number of their eyes, spiders as a rule are by no means keen-sighted, and depend more often upon their sense of touch than on their powers of vision.

At the end of, and just beneath, the abdomen the spider carries her spinnerets. These are normally six in number, usually arranged in the form of a rosette. Mounted on each of the spinnerets are a quantity of spinning spools, or tubes, usually from sixty to seventy in number, out of which the silk flows. The spools are connected with the silk glands in the spider's abdomen, in which the silk is secreted in a liquid state, and this fluid, on coming in contact with the air, hardens into a silky thread. The silk glands vary in different families of spiders, reaching the highest state of development in the Orb-weavers, which possess an extraordinary number; the big Garden spider (*Epeira diademata*) has nearly seven hundred. The silk secreted in these glands is not all of the same quality, and the spider, by using different sets of glands, is able to vary the texture and colour of her threads to suit the particular kind of work upon which she happens to be engaged. Spiders vary in their spinning powers to a very great degree, some weaving the most finished and ingenious snares, others but rough and rudimentary webs. Some

spiders make no snares, and use their silken threads only to construct a cocoon for the protection of their eggs.

The egg-bags or cocoons of spiders vary very much in appearance, but they are all commenced in much the same way. The spider first weaves a small, soft pad of silk, on which she deposits her eggs, and then covers them carefully with a second pad, opening her spinnerets to the fullest extent and pouring out a regular shower of silk, which she spreads out and beats down with her hind legs. Some species are content in this way to surround their eggs with a fluffy ball of silk; others construct the most elaborate caskets further to protect them from egg-eating creatures and the inclemency of the weather. The big European Banded Spider fashions hers in the shape of a balloon and suspends it in an inverted position from tall grasses, attached by strong silken cords. Several different coloured silks go to the making of this dainty egg-case, white, russet, brown, and black; the neck of the tiny balloon is most beautifully and evenly scalloped, and the whole ornamented with a glossy silken ribbon laid on in a zigzag pattern. Some species make their cocoon in the form of tiny kettledrums, the closely woven and tightly stretched silken cover being as smooth and taut as parchment. Other cocoons are like wine-glasses, flat pie-dishes, or cones, each particular species having its own hard-and-fast ideas on the important subject of egg cocoons.

The egg-bags when completed are attached to twigs and foliage or tucked away into some sheltered nook, such as a crevice in an old wall or under the loose bark of a decaying tree trunk; in such a situation we may often find the large, fluffy, golden-coloured egg-cocoon of the common Garden Spider. Some spiders, instead of trusting all their eggs to one large cocoon, construct several small ones, and, instead of hiding them away, string them in chains between two of the upper spokes of the web from which the spiral threads have been removed. The American Tailed Spider (*T. caudata*) adopts this plan, and furthermore adorns her cocoons with the wings and legs and other indigestible portions of the insects she entraps in her snare.

Covering the egg-cocoons with the debris of their victims or other odds and ends, such as fragments of leaves, bits of straw, grass, etc., is by no means an uncommon practice among spiders; some species, after making the daintiest of receptacles to hold their

eggs, daub them all over with mud, the better to hide them from prying eyes.

The Wolf Spiders (*Lycosidæ*) carry their cocoons about with them wherever they go, often attached to their spinnerets. These spiders are hunters, and may often be seen pursuing their prey with their large white egg-bags bumping along over the ground behind them. When the young Wolf Spiders are hatched they mount on to their mother's back, and stay there clinging tightly to her soft hairs for about a week, when they disperse and begin to hunt on their own account.

Spiders do not undergo a metamorphosis. But although a spider *is* a spider directly it hatches from the egg, it differs in several ways from the mature animal, and it is not until after a series of moults that it becomes a perfect spider. When a young spider first emerges from the egg, it is swathed in a membranous sheath which covers it completely, so that the mouth and spinning tubes are closed. This membrane the newly-hatched spider throws off before it leaves the cocoon, and the operation has been described as follows:[1] "While it held on to the glossy nest with the two front and third pair of legs, the hind pair was drawn up and forward, and the feet grasped the upper margin of the sac-like shell, which, when first seen, was about half-way removed from the abdomen. The feet pushed downwards, and at the same time the abdomen appeared to be pulled upward until the white pouch was gradually worked off."

Soon after the young spider has cast its first skin it usually leaves the shelter of the cocoon, although in some cases it may remain there for some little time. Whole families of young spiders belonging to the Orb-weavers (*Epeiridæ*) live together amicably for a week or two before they disperse, and during this period they do not feed. As soon as a desire for food is awakened the young spiders begin to prey on the minute forms of insect life round about, and if this happens to be scarce they will proceed to devour each other. It is obvious that large families of spiders, each numbering perhaps several hundred, cannot live and fare well if they all settle down in close proximity to one another. It is necessary that they should seek new hunting grounds as far apart as possible, and it is the custom in many families of piders for the young ones

[1] M'Cook: "American Spiders and their Spinning Work."

to set off on their first adventurous journey by air. In the spring and in the early autumn quantities of these tiny aeronauts may often be seen crowding on the tops of walls and fences preparing for their flight.

When about to set out on its aerial journey the young spider faces the wind and straightens out all its eight legs, raising its body as high as it can in the air. Then from its spinnerets it begins to pay out a long, continuous thread of silk which is borne lightly away on the breeze. As soon as the little creature feels, by the pull of the silk, that its craft is strong enough to bear its weight, it grasps the threads with its legs and lets itself go, and is wafted away to new ground.

Before reaching maturity a spider usually goes through about nine moults. Casting the skin is often a considerable effort to the animal, and in its struggles it occasionally loses a limb; but this is not such a serious matter to a spider, for it has the power of reproducing lost parts, and at the next moult the limb will be replaced by a new though somewhat smaller one.

The mating customs of spiders are often very curious, and courtship in many species is fraught with considerable danger to the little male, who is almost invariably a great deal smaller than the female, for if the lady does not approve of his advances she is almost certain to devour her admirer. Among the *Epeiridæ* (the Orb-weavers) the difference in size is most extraordinary, the female in some cases being a thousand times greater in bulk than her tiny mate. In some species, however, the male, although smaller in body, has a greater length of leg than the female, and he is often much more brilliantly coloured and sometimes adorned with wonderful plumes and brushes, the better to please the eye of his savage mate.

Male spiders appear to be greatly outnumbered by the females, and this is actually the case to a certain extent; but the smaller size, the restless habits and comparatively short life of the males render them much less noticeable than the large and sedentary females. In the mating season the males suddenly appear in numbers, and may be seen lurking on the borders of the snares woven by the females. They will wander timidly round and round the domain of the lady for hours before they dare venture to set foot on the lowest rings of her web, and a sudden move-

ment on her part sends them scurrying off in the greatest alarm. Sometimes the male will spin a little web of his own on the edge of his lady's snare, and there patiently await a favourable moment, when she shows signs of being in a softer mood, for pressing his attentions. But the diminutive male, if weak and timid, is not lacking in perseverance, and he will return again and again to the attack after each repulse. A naturalist, after watching the manœuvres of these tiny spiders, writes: "In these encounters the males are often injured; they frequently lose some of their legs; and I have seen one that had only four out of his eight left, still standing up to his work."[1]

The male Leaping Spiders (*Attidæ*) go through the strangest antics to attract the attention of the uncertain-tempered females, who seem very much to admire the performance. In tropical countries these spiders are brilliantly coloured, some shining with wonderful iridescent hues. Russel Wallace has described those he saw in the Malay archipelago as "perfect gems of beauty."

Some spiders are less savage in their ways, and the males and females of certain sedentary species may be found living together in harmony during the mating season.

Spiders may be roughly classed as sedentary, or wandering; the former weave snares to entrap their victims, the latter hunt their prey on foot. Spiders' webs vary as much as do the nests of birds, and range from the tangle of irregular threads laid down without any particular design by the "Line-weavers" to the wonderfully symmetrical and elaborate snares of the "Orb-weavers."

The family *Epeiridæ* includes all those spiders that spin circular or wheel-like snares; and from the remarkable regularity of their work the little weavers are often called "Geometric" Spiders. The common Garden Spider, *Epeira diademata*, is a typical Orb-weaver, and her large, round web is a familiar object in early autumn. She commences her work by laying down a few foundation threads. She may lay the first one down "by hand" by the simple method of fastening her silk to a selected point and walking away with her thread trailing behind her until she reaches a suitable spot to which to fix the other end of her line; or she may decide to trust to chance, and, facing the wind, allow her thread to be wafted away until it is caught

[1] Emerton, "Spiders, their Structure and Habits."

on some projecting twig. Having fixed a sufficient number of foundation lines in place she puts in the spokes of the wheel, stretching the threads across the framework so that they all meet in the centre. The hub of the wheel is next strengthened by a few rings of silk which serve to bind the spokes firmly together, and then, starting from this central point, the spider works in a spiral scaffolding with the successive rings rather wide apart. The most important part of the snare has now to be woven in; starting at the circumference, and working her way upwards, she puts in the viscid spiral rings on which the capture of her prey depends. The foundation lines, the spokes, and the scaffolding are of ordinary dry silk; but the final rings are formed with silk which is covered with a gummy secretion. As the spider swings from point to point on her scaffolding she stretches this thread, which is highly elastic, as tightly as possible, and at the moment of fixing it to one of the radiating lines lets it go with a snap. This causes the coating of viscid matter to form into a number of tiny globules all along the thread, which, seen through a pocket lens, has the appearance of a string of beads. The web now being complete, the spider either takes her stand in the centre or retires to a position close at hand, often under a sheltering leaf, to await the reward of her labour.

Some Orb-weaving Spiders ornament their snares with tufts of flossy silk, while other species work in a broad ribbon of flossy silk in a zigzag pattern between two of the spokes of the wheel, like a winding staircase. The North American Orb-weaver (*Argiope cophinaria*) finishes her snare in this way, and she also works in a central shield behind which she sometimes takes her stand to conceal herself from possible victims or enemies.

Some of the snares constructed by spiders are marvels of ingenuity. The Triangle Spider, *Hyptiotes cavatus*, makes a regular spring trap. From one foundation line the spider draws four radiating lines converging to a point. These are connected by cross lines which are not of a sticky nature, but are fluffed and teased out in the process of spinning. From the apex of the triangle a line is carried to an object a little distance away, and on this the spider takes up her position, back downwards, facing her trap. She then hauls in the line until it is quite taut and waits until a trembling of the thread tells her of the arrival of a

victim. Then immediately the spider lets go the line with her forelegs, and the released web springs back on the fly, thoroughly entangling it in the fluffy meshes. If the victim is unusually large and strong the spider will often spring her trap two or three times to prevent it escaping.

Another spider, *Epeira basilica*, constructs a dome-shaped web, which strongly resembles an open umbrella; under this, moreover, she spreads a sheet of irregular threads, and above the dome she weaves a mass of threads in the form of a pyramid.

Sheet webs are the work of the Labyrinth Spiders (*Agelenidæ*). To this family belong the common, long-legged House Spiders, which are responsible for the cobwebs that accumulate in outhouses and disused rooms. The webs of an outdoor species are often seen in numbers on the hedgerows and the banks of ditches in country lanes.

The Line-weavers, to which the greater number of British spiders belong, weave a medley of fine lines, running in all directions among the grasses or over bushes; and although of such rudimentary construction, these webs effectively arrest and hold many an insect that chances to fall into them.

Some spiders, instead of weaving an open snare, make their homes in cracks and crannies in walls or rocks, in which they construct a closely woven tubular nest. Others are vagabonds, roving about from place to place, and have no special place of abode; but there are very few species that have not some sort of nest, or retreat of one kind or another. Many forms live in burrows in the ground, and of these the most famous are the Trap-door Spiders (*Avicularidæ*).

The Trap-door Spiders possess very strong jaws, and with them they dig in the ground a hole several inches deep. The hole is lined with a tube of silk, and the entrance is fitted with a door, which may be either a thin, circular wafer of silk or a thick plug like a cork, composed of alternate layers of silk and earth. The door is attached to the mouth of the burrow by a hinge of silk, and opens outwards; so that when closed it is practically impossible for an enemy to open it, particularly as the spider is in the habit of clinging to the inside of the door with her legs and firmly holding it down when she is alarmed.

Several other ingenious forms of nest are constructed by

different species of burrowing spiders. The Turret Spider (*Lycosa arenicola*) erects a little turret above her tunnel of twigs and tiny stones, and from this little watch-tower she may sometimes be seen on the look-out for prey as evening approaches; for, like other burrowing spiders, the Turret Spider is nocturnal in its habits.

To this group of spiders belong the great, hairy Mygale Spiders of tropic lands, commonly called "Bird-eating" and "Tree" Spiders. They are huge creatures, some species spanning 7 inches with their legs, and are decidedly alarming in appearance. These spiders live in burrows in the ground, under stones, or in hollow trees. They have been known occasionally to kill small birds, but they prey chiefly on large species of insects, and are not so dangerous as is commonly supposed.

The Tarantula Spider of Southern Europe, whose bite in bygone days was supposed to cause a curious dancing madness, is a large species of Wolf Spider (*Lycosidæ*). Although exceedingly venomous, the tales of the terrible results following the bite of this creature have been greatly exaggerated; and although large insects, such as bees and wasps, are instantly killed by a nip from the Tarantula's fangs, and experiments have proved that small animals (young birds, moles, etc.) do not survive it for very long, it is not remarkably serious, and only in exceedingly rare cases fatal, to man.

The Water Spider (*Argyroneta aquatica*), although an air-breathing animal, spends the greater part of its life under the water. The abdomen of the little creature is clothed with long, silky hairs, in which minute bubbles of air are imprisoned, so that as it swims and dives in the water the spider appears to be coated with quicksilver, and the film of air with which it is surrounded enables it to breathe comfortably while beneath the surface. This spider constructs a little dome-shaped nest of closely-woven threads, securely anchored to water-plants beneath the water, and this she fills with air in the following manner: "The spider ascends to the surface and for a moment sticks her body out into the air; she then rapidly descends, taking with her a supply of air imprisoned by the fine hairs covering her abdomen. She at once enters her nest, and proceeds to comb out the imprisoned bubbles with the aid of her comb-like feet. Again and again

she visits the surface and returns with a fresh supply of air, which she at once discharges under her dome-shaped nest until it becomes inflated by the air, after the fashion of a diving-bell, and looks as if it were filled with quicksilver. Within the diving-bell home the spider spends the greater part of her life, only quitting it in search of food, or to bring down a fresh supply of air to replace that which has become exhausted." [1]

" Harvest-spiders " or " Harvestmen " (*Opiliones*), as the long-legged spiders frequently found creeping over the walls in dwelling-houses in the autumn are popularly called, are not true spiders. The cephalothorax and the abdomen are fused together so that the body of a Harvestman has the appearance of a small, round button. There are several species of *Opiliones*, most of which are rather small, but some found in South America reach exceedingly large dimensions, while others are very grotesque in shape.

The order **Acari,** Mites and Ticks, includes a vast number of forms, most of which are very minute. A few species are ½ inch or more in length, but the majority of the *Acari* are extremely small, some species being invisible unless viewed through a magnifying glass. In spite of their small size, however, the *Acari* are of considerable economic importance. They attack plants, doing a vast amount of damage to crops of all kinds; many are parasitic on animals; and in tropical countries they often act as transmitting agents of certain diseases to man and domesticated animals.

All Mites undergo a metamorphosis, many passing through several stages before arriving at the adult state. They vary somewhat in form; in some the body is sac-like, and appears to have no division; while in others the body is distinctly divided into two parts—the cephalothorax and the abdomen. The legs are normally eight, but may be as few as two in number, and eyes may be present or entirely absent.

The Red Spiders and the Gall-Mites are only too well known to fruit-growers from the damage they cause to fruit trees and bushes; poultry-keepers are familiar with the species which attack domestic fowls; while most people who pay visits to the country are acquainted with the " Harvest-Mite," the micro-

[1] F. Martin Duncan: " Our Insect Friends and Foes."

scopic pest that burrows under the skin and causes such painful and irritating swellings in the early autumn days.

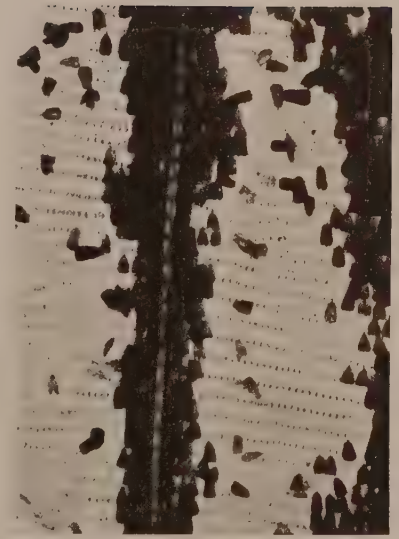
Occupying a unique position between the ringed worms on the one hand and the Myriapoda and insects on the other is a remarkable genus termed **Peripatus.** In appearance these creatures resemble the millipedes. They have worm-like bodies furnished with a number of clawed feet, rather like the pro-legs of a caterpillar; these vary in number, according to the species, from seventeen to forty-three pairs. The bodies of these creatures are clothed with a soft, velvet-like skin, and the head, which is not distinctly marked off from the body, bears a pair of wonderfully mobile antennæ, a pair of simple eyes, and a mouth furnished with jaws on the under side. They also possess a pair of oral papillæ, from which, when irritated, they eject an extremely sticky, milky fluid. This fluid can be squirted to a distance of a foot, and, although harmless, is sufficiently tenacious to hold fast flies and other small insects. These strange creatures live in moist, shady places under stones, leaves, or the bark of trees. They are nocturnal in their habits, and when walking move straight forward as a caterpillar does, and never wriggle like a worm or a centipede. Paripatus has a wide distribution, but from its habitual avoidance of light it is very rarely seen.

The class **Myriapoda** comprises the familiar Centipedes and Millipedes. These creatures are found in almost all parts of the world; they are a hardy race, able to endure extremes of both cold and heat, and flourish equally well on fertile and barren soil. The two classes of Myriapoda are often confused one with another, but although both millipedes and centipedes possess a worm-like, segmented body, they differ from one another in many ways, both in structure and habits. The two classes may always be readily distinguished by the arrangement of their paired legs, the millipedes having two pairs on each body segment, while the centipedes have only one.

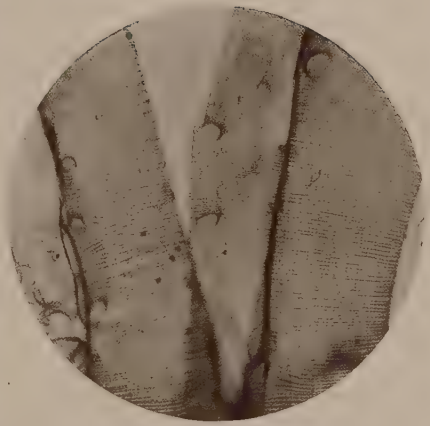
Centipedes are carnivorous, very active and ferocious, and are often useful rather than harmful, as they destroy many troublesome pests. Just below the mouth they have a formidable pair of poison claws, and with these they seize and kill their prey. They devour insects and worms, and frequently fight fiercely among themselves. Centipedes vary very much in size and colour.

Tarantula and Mygale Spiders

Two female Garden Spiders and a male Spider



Wing of Butterfly, showing tile-like arrangement of scales



Tracheal Tubes of Caterpillar

A Spiracle or " breathing pore " of Caterpillar

some species being so minute that one can hardly see them without a pocket lens, while others are over 6 inches long. They may be short and broad, with a body composed of only a few segments, or long and thin, with over a hundred. The majority are dull in hue, rusty brown or black; yet some foreign species are streaked with vivid colours. A few are phosphorescent, leaving, as they move swiftly over the ground in the darkness, a gleaming trail of light in their wake. Stories have been told of gigantic centipedes over a yard long, whose bite is fatal to man and beast; but these tales may be put down as travellers' yarns.

Millipedes, on the other hand, are as a rule quiet, inoffensive creatures. They have no poison claws, and are entirely vegetable feeders, but for this reason they are often very destructive to crops. As a means of defence they are provided with special glands (commonly called "stink glands") which secrete an exceedingly disagreeable fluid. The female millipede makes a curious kind of nest below the ground, composed of pellets of earth moistened with the sticky fluid from her salivary glands. In this she deposits her eggs, usually from about sixty to one hundred in number, passing them through a small hole left in the earthen ball. She then closes the opening with another pellet of earth, and takes no further interest in the fate of her offspring.

The male centipede (in some species) is given to cannibalistic habits, and as soon as the female lays an egg he endeavours to seize and devour it. But this unnatural desire the mother centipede does her best to frustrate. At the end of her body she has a pair of small, movable hooks; with these she clasps the egg and sets off with it as fast as she can; then when she has outstripped her mate, she quickly rolls the egg, which is covered with a sticky secretion, round and round in the earth, until it has the appearance of a tiny pellet of mud. Then, having in this way hidden it from the voracious male, she leaves it to its fate.

CHAPTER IX

BUTTERFLIES AND MOTHS

THE order **Lepidoptera**[1] includes the Butterflies and Moths, insects to which a great deal of attention has been given, not only on account of their beauty of form and coloration, but also for their economic importance, for while some are of considerable value to man, others during the larval stage of their life cause fearful havoc to his crops, so that it is not surprising to find that at least fifty thousand species have already been described. They pass through a complete metamorphosis—egg, larva (or caterpillar), pupa (or chrysalis), and perfect insect—and are easily distinguished from all other insects in the adult stage by their four wings covered with scales, which are arranged like the tiles on a roof (see illustration facing p. 139), and vary in shape and in colour.

The larva or caterpillar is generally cylindrical in shape, and consists of thirteen divisions, the first of which is the head, the next three are the thoracic segments, each bearing on the under surface a pair of true legs, and the rest are the abdominal segments. Besides the six true legs, the larva is furnished with from one to four pairs of fleshy "pro-legs" on segments 7—10, and an additional pair, called "claspers," which terminate the last segment. Each body segment, except the first, third, fourth, and last, is provided with a small opening on each side, above the feet, which is surrounded by a horny margin. These openings, through which the insect breathes, are called *spiracles*, and they communicate within with a series of breathing-tubes or tracheæ. Many caterpillars are quite smooth-skinned and naked, or only thinly covered with hair, while others are covered with a close pile, or with thick, long hairs; or they have tufts of hair; while others, again, are furnished with humps, warts, or tubercles, varying in

[1] Greek, *lepis*, a scale; *pteron*, a wing—scale-winged insects.

size, number, and position. The caterpillar casts its skin repeatedly, the number of times varying in different species, and, except at the period of moulting, feeds voraciously. The food of caterpillars is very various, and although the majority are probably purely vegetable feeders, they will also feed upon leather, horn, hair, cloth, wool, etc.

Caterpillars have many foes, being preyed upon by birds, wasps, and insectivorous animals; but their most formidable enemies are the ichneumon flies, which pierce their skins, and deposit one or more eggs in each wound. These eggs soon hatch into small maggot-like larvæ, which live inside the caterpillar, feeding on the fatty portions of its body, while avoiding any vital organ; when mature they may either emerge from the caterpillar's skin and assume the pupa state outside the dead body of their host, or, should the caterpillar live to enter the pupa state, they may pass through their complete metamorphosis within the body of their host. The caterpillars have various means of defence or concealment from their foes, some closely resembling twigs of the foliage upon which they are feeding; others by warning colours, eye-spots, and vivid bands of colour deceive their enemies, or by assuming aggressive and threatening attitudes avoid attack, or by being clothed with irritant hairs, or having an unpleasant odour or taste, are immune from molestation.

When the caterpillar is full grown, and is ready to assume the pupa state, it ceases to eat, its colours become less brilliant, and it seeks a suitable place where undisturbed it may undergo its metamorphosis. While the caterpillars of most butterflies attach themselves by their tails either horizontally or vertically to some plant stem, to change to the pupa stage, the caterpillars of many moths construct a silken cocoon, or excavate a cell in the ground, lined with agglutinated earth and silk. Hairy caterpillars often weave their hairs into their cocoons, while others use fragments of moss, leaves, lichens, and wood. The duration of the pupa state varies greatly in different insects, but, except in the case of summer broods of double-brooded insects, when it may last only a few days, it extends over a period of several months, the insect usually passing the winter in this condition. During the pupa stage not only are the external organs of the future

perfect insect developed, but both the digestive and nervous systems undergo profound modification. Finally, these wonderful changes completed, the skin of the pupa cracks, and the perfect winged insect emerges. At first it is limp and weak, its abdomen is thick, and its wings are damp and in a rudimentary condition; but the insect crawls to a position near its old pupa-skin, where it can allow its wings to hang down, when they very rapidly expand to their full size and beauty. Here the insect rests for a short time, to allow its body, legs, and wings to dry and harden, and then flies away to enjoy its comparatively short life; for while the larval stage, as in the Goat Moth, for example, may last for two years, the perfect-winged state only lasts for a few weeks at the most, except in the case of those insects which, emerging from the pupa stage in late autumn, spend the winter in hibernation, awakening with the return of spring to mate and spend a few hours of happy flight in the first warm sunshine of the year.

In the perfect state a butterfly or moth has four wings, more or less thickly covered with scales, but in some groups of moths the females have only rudimentary wings, and are quite incapable of flight. The antennæ, which are such conspicuous appendages of the head, appear to be organs of touch, hearing, and smell. They are composed of a great number of joints, and in the butterfly they are long and straight, and are thickened into a club at the extremity. In the moths the antennæ are sometimes thread-like, or they may be dentated, serrated, comb-like, or plume-like. The sexes often differ in the development of the antennæ, and in this case those of the male are always more highly developed than those of the female. The proboscis or tongue forms a coiled spiral tube when not in use, but can be stretched out and thrust into the corolla of a flower when the insect is seeking a sip of nectar. It is made of two separate pieces throughout its entire length, so that it can be separated and cleaned if necessary.

Butterflies and moths have a world-wide distribution, and are exceedingly numerous in species. They are most numerous in the warmer parts of the world, in those regions where the vegetation is most varied and luxuriant. In tropical America butterflies abound, more than half of all the species known inhabiting this part of the world; over two thousand different kinds have been collected from the Amazon region alone. It was in this

Larva of Privet Hawk Moth

American Silk Moth and cocoons

Life-history of the Swallow-tail Butterfly

wonderful country that Mr. H. W. Bates made his first observations on the warning colours and mimicry of insects. In his "Naturalist on the River Amazon" he gives the following account of a species of Hawk-Moth, so like a humming bird in colour, shape, and mode of flight, that it cannot be distinguished from the bird when on the wing: "Several times I shot a Humming Bird Hawk-Moth instead of a bird. This moth (*Macroglossa Titan*) is somewhat smaller than the humming birds generally are; but its manner of flight, and the way it poises itself before a flower whilst probing it with its proboscis, are precisely like the same actions of humming birds. It was only after many days' experience that I learnt to distinguish one from another when on the wing. This resemblance has attracted the notice of the natives, all of whom, even the educated whites, firmly believe that one is transmutable into the other. They have observed the metamorphosis of caterpillars into butterflies, and think it is not at all more wonderful that a moth should change into a humming bird. The resemblance between the hawk-moth and the humming bird is certainly very curious, and strikes one even when both are examined in the hand. Holding them sideways, the shape of the head and the position of the eyes in the moth are seen to be nearly the same as in the bird, the extended proboscis representing the long beak. At the tip of the moth's body there is a brush of long hair-scales resembling feathers which, on being expanded, looks very much like the bird's tail. But, of course, all these points of resemblance are merely superficial. The negroes and Indians tried to convince me that the two were of the same species. 'Look at their feathers,' they said; 'their eyes are the same, and so are their tails.' This belief is so deeply rooted that it was useless to reason with them on the subject."

The Lepidoptera, both in the caterpillar and perfect stage, afford some of the most striking and remarkable examples of warning colours and protective mimicry. Bates was the first to draw attention to the real significance of the close superficial resemblance which insects belonging to very different groups frequently bear to one another. His observations were conducted during his long sojourn in tropical America, where he was able to prove that the abundant and conspicuous but nauseous butterflies belonging to the families *Heliconidæ* and *Danaidæ* are closely

mimicked by *Pieridæ* and other butterflies, and by some day-flying moths.

A most remarkable example of mimicry exists in a South African Swallow-tail Butterfly (*Papilio cenea*). The male insect possesses the characteristic tails to its hind-wings, but these are not present in the female, and she is utterly unlike her mate in the colouring and form of her wings. Three varieties of this female are known, each closely mimicking three different species of the genus *Danais* which have been proved to be distasteful to insect-eating birds. The Indian and African butterfly *Hypolimnas misipus* is another interesting example in which the male is non-mimetic and quite unlike the female ; the latter mimicking the nauseous *Danais chrysippus*. It would appear that the females are far more often mimetic than the males, and Wallace accounts for this by the fact that they are especially open to the dangers of attack, owing to their slower flight when heavy with eggs and when resting on the leaves of the plants upon which they deposit their eggs.

The mimicking insect almost invariably belongs to an edible variety that but for its remarkable resemblance to the unpalatable or dangerous species it copies would readily fall a prey to insect-feeders. It is this form of protective resemblance which constitutes *true* mimicry, and Wallace has defined the following general condition as being characteristic of this class of protected insects : " (1) That the imitative species occur in the same area and occupy the very same stations as the imitated. (2) That the imitators are always the more defenceless. (3) That the imitators are always less numerous in individuals. (4) That the imitators differ from the bulk of their allies. (5) That the imitation, however minute, is *external* and *visible* only, never extending to internal characters or to such as do not affect the external appearance."

Several of our British Clearwing Hawk-Moths mimic different species of Hymenoptera. Thus the Bee Hawk-Moths (*Bombyliformis* and *Fuciformis*) closely mimic the humble-bees, with whom they may be seen in company on sunny days in early summer, hovering over azalea and rhododendron flowers. The Hornet Clearwing Hawk-Moths copy so closely in appearance the formidable hornet that it takes a very practised eye to detect the one insect from the other while they are on the wing.

INDIAN LEAF BUTTERFLY (*KALLIMA INACHIS*)

Warning colours are particularly noticeable in many caterpillars, and the more conspicuous and gaudy the appearance of the insect, the more distasteful it is generally found to be. Although so plump, the handsome larva of the Privet Hawk-Moth, with its bright bars of colour, is left severely alone by the insect-eating birds, who also will not touch the larva of the Magpie or Gooseberry Moth, with its striking black and orange markings.

A very large number of our British moths which sleep or remain dormant during the daytime have the markings and coloration of their wings so similar to the general tone of their favourite resting-place as to render them practically invisible at a few yards' distance. The Lappet Moth, the Buff-tip Moth, the Old Lady Moth, and the Pine Hawk-Moth may be mentioned as common and familiar examples from a very long list of protectively coloured British moths.

A most remarkable example of protective mimicry is that of the Indian Leaf Butterfly (*Kallima inachis*), which, when at rest with folded wings, has an extraordinary resemblance to a dead leaf. It is a large and handsome insect, the upper surface of the wings being a fine bluish or purplish colour, with a transparent spot in the middle of the fore-wings, beyond which a broad orange band in some species, or a bluish-white one in others, runs obliquely from the front edge of the fore-wings nearly to the hinder angle. The fore-wings are more or less pointed, and the anal angle of the hind-wings is produced into a short, blunt tail. The under surface is brown, with a dark streak resembling a midrib running from the tip of the fore-wings to the tail of the hind-wings. The surface is irregularly streaked and mottled, and Mr. A. R. Wallace describes the Sumatran species as being invisible when at rest, from its resemblance to the dead leaves among which it always settles. The butterfly sits with its wings over its back, and its head and antennæ raised and hidden between them, while the tails of the hind-wings rest upon the branch, corresponding exactly in appearance with the stalk of the leaf.

To the family **Nymphalidæ** belong quite half the known butterflies, including the *Danaidæ* already mentioned, and the glorious metallic blue genus *Morpho* of South America. The second subfamily of the *Nymphalidæ*, the *Satyridæ*, contains at least a

thousand species of chiefly small or medium sized and somewhat sombre-hued butterflies. The majority have eye-like spots upon the under surface of the wings; similar spots are sometimes seen on the upper surface. The caterpillars feed on different grasses, and are generally green in colour, with a forked tail. The Marbled White, the Scotch Argus, the Wall Brown, and the Meadow Brown are familiar examples.

The true Fritillaries are very beautiful butterflies of rich brown colour with black spots and bars on the upper surface, and spotted or streaked with silver on the under surface of the wings. The Pearl Bordered, the Silver Washed, and the High Brown are fairly common English forms. The Vanessa Butterflies, of which the Peacock, Red Admiral, and Tortoiseshell are familiar examples, are very handsome insects; their caterpillars are cylindrical, covered with long branching spines, and live, chiefly, gregariously on nettles.

The beautiful Swallow-tail Butterfly (*Papilio machaon*) is our only British representative of a very gorgeous family, the members of which attain their greatest size and most resplendent colouring in the tropics. Formerly the Swallow-tail Butterfly seems to have been widely distributed throughout England, but now it is restricted to one or two localities of the fens of Norfolk and Suffolk. The caterpillar feeds upon fennel and wild carrot, and is at first black, becoming green with black rings spotted with red as it increases in size. When alarmed, it has a curious habit of suddenly poking out two horn-like processes from between the head and the first segment of the body, and at the same time giving off a faint smell.

The **Pieridæ,** popularly called Cabbage Butterflies, have a wide distribution, being found in Europe, Asia, Africa, and Australia. The great Cabbage White Butterfly (*Pieris brassicæ*) is to be seen in every field and garden. The caterpillar is a great pest to the agriculturist, making sad havoc amongst the cabbages, and is not a pleasant-looking nor a nice-smelling insect. Its greenish body, marked with three long yellow lines broken into here and there by little black hairy tubercles, is only too familiar in the kitchen garden. The caterpillars are not solitary in their habits, but abound in swarms, eating their way into the hearts of the cabbages and rendering them unfit for market. Fortunately for

the farmer, they are preyed upon by a little ichneumon fly (*Microgaster glomerator*), which deposits its eggs beneath the skin of the caterpillar, who thus serves as a living host.

Butterflies play an important part, though probably not quite so great as the moths, in fertilising flowers, their long, slender probosces being admirably adapted for probing the nectaries of many flowers, and in their passage transferring the pollen from the anthers of one flower to the stigma of another of the same species. So that although some of them during the caterpillar stage ravage our crops, as perfect insects they make recompense by acting as the carriers of pollen from flower to flower.

Moths are far more numerous than butterflies, some forty to fifty thousand species of the former being known and only ten or twelve thousand of the latter. Many of the moths in their caterpillar stage do a very great deal of harm to root and garden crops, to stored grain, and to cloth and fur. Reference has already been made to the protective colouring and mimicry of many moths.

The great family of **Sphingidæ**, or Hawk-Moths, includes a number of large and handsome insects. To this family belong the Humming Bird Hawk-Moth and the Bee and Hornet Hawk-Moths already mentioned. Many of the large Sphinges feed on the vine, and of these perhaps the best known is the pretty Sharp-winged Hawk-Moth (*Chærocampa celerio*), which is common in many parts of Europe, Asia, and Africa, and has pale brown front-wings and beautiful rose-coloured hind-wings. The caterpillars have the front segments tapering and retractile, which gives them a fancied resemblance to a hog's snout (from which they gain their Greek name *Chærocampa*), or an elephant's trunk, whence the name Elephant Hawk-Moth applied to two smaller and commoner species. The Death's Head Hawk-Moth is the largest moth found in Great Britain, and gains its popular name from the curious somewhat skull-like pattern on its back. It is capable of producing a sound resembling the squeaking of a mouse, and will sometimes enter hives to feast on the honey. The great yellowish-green caterpillar may be found feeding on the foliage of the potato.

The Tiger Moths (**Arctiidæ**) are the most beautiful family of moths found in Europe. The Common Tiger Moth is typical of the group. It measures from 2 to 3 inches across the front-wings, which are deep brown with creamy white interlacing mark-

ings ; the hind-wings are a rich red with black spots. The caterpillar is popularly known as the "Woolly Bear," and is covered with tufts of long black hair tipped with white.

The Vapourer Moth (*Orgyia antiqua*) is of interest not only as an agricultural pest, but because the female has only rudimentary wings, and looks almost like a misshapen spider. The Puss Moth and the Lobster Moth are both of interest on account of their remarkable caterpillars. That of the Puss Moth has only fourteen legs, the claspers being replaced by two long slender tubes, from which, when the insect is angry or alarmed, two wavy red filaments are protruded, and are used to frighten away the ichneumon flies that attack it. It is a large handsome caterpillar when full grown, of a delicate green with a purplish brown back, bordered by a band of white. The head is large, and the third and fourth thoracic segments are raised up into a hump. The caterpillar of the Lobster Moth is chestnut-brown, with enormously long legs, and the hind part of the body swollen out into a curious shape somewhat resembling the claw of a lobster, from which the insect takes its popular name.

The Processionary Moth (*Cnethocampa processionea*) is frequently met with on the Continent, where the caterpillars, which are bluish-black on the back, and whitish on the sides, feed gregariously on oaks. They form a common web, in which they remain quietly during the day, but at sunset come forth to feed, issuing in regular order, first one, then another, then a third, and then comes a rank of three or four individuals, which is followed by one of many more, and so on, the ranks ever increasing in number. After feeding the same order is taken up, and the caterpillars march back to their web in the same formation. These caterpillars are covered with fine barbed hairs, which, as well as the dust in the webs, are terribly irritating to the skin, producing very painful swelling and inflammation.

The family **Saturniidæ** is a very important one, for it contains some of the largest moths in the world, and, with the exception of the Mulberry Silk Moth, which belongs to the family *Bombycidæ*, contains all those moths whose caterpillars produce silk of commercial value. The Oak-feeding Silkworm (*Antheræa yamamai*) yields a large and beautiful cocoon of excellent quality from which a great deal of the silk used in Japan is manufactured.

BUTTERFLIES SHOWING WARNING COLOURS AND MIMICRY

1. *Prioneris sita* (under surface)
2. *Delias eucharis* (under surface)
3. *E. Andamana* (day-flying moth with warning colours)
4. "Owl-face" Butterfly (eye-like spots on wings)
5. *Heliconius*
6. *Melinæa*
7. *Hypolymnas* (male)
8. *Hypolimnas* (female)
9. *Limnas* (distasteful to birds, and mimicked by female *Hypolimnas*)

The Japanese Government long reserved the monopoly of this insect to Japan, death being the penalty for attempting to export it from the country. Several other closely allied species are used for the production of silk, *Antheræa pernyi* being used in Northern China, and *Antheræa mylitta*, the Tusseh Silkworm, in India. The Mulberry Silkworm (*Bombyx mori*) was originally a native of China. It was first introduced into Europe in the reign of Justinian by some missionaries who smuggled the eggs to Constantinople. The rearing of the silkworms soon became common, and has ever since formed one of the staple industries of Southern Europe. The only British species belonging to the family *Saturniidæ* is the well-known Emperor Moth (*Saturnia carpini*); it is allied to the Great Peacock Moth (*Saturnia pyri*), which measures 6 inches across the wings, and is the largest moth found in Europe.

The **Geometræ** is a large group of moths, the larvæ of which are popularly called "Loopers," on account of the peculiar manner in which they walk. The caterpillars fix themselves firmly by their last pair of pro-legs and their claspers, and stretch out their slender bodies to their full length; then, obtaining a hold with the six true legs, they let go the hinder ones, which they now draw up close to the front ones, thus arching the body into a loop; and the process is repeated again and again. Their mode of rest or attitude when alarmed is no less singular; fixing themselves by their hind-legs and stretching their bodies stiffly out at right angles to the branch, they remain absolutely motionless for a very long time, and in this position, aided by their shape and coloration, so closely resemble a dead twig that they often escape observation and elude their foes.

In the above very brief outline of the Lepidoptera little has been said about the anatomy of true insects, and therefore it will be as well now to give a short description of the chief points of interest, so that the reader may be made familiar with certain terms which are used to describe the various parts of the body of all true insects.

"The material[1] of which the external coverings of insects are composed is called chitine, and carbonises and retains its form when exposed to a very high temperature—a simple test which proves the difference of its composition as compared to horn,

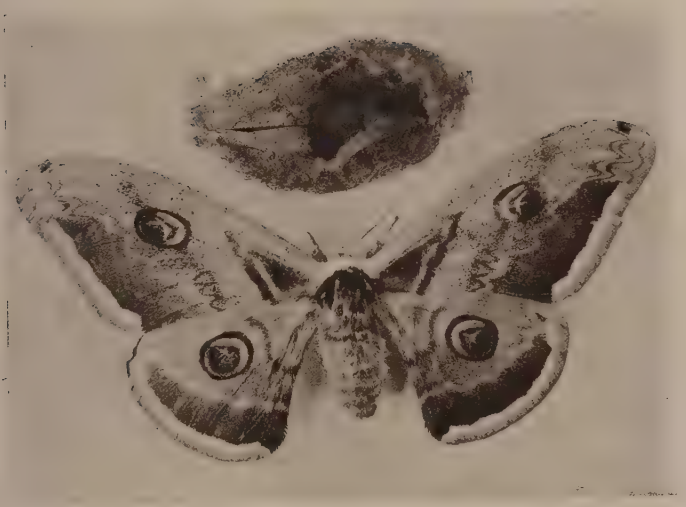
[1] F. Martin Duncan, "Insect Pests of the Farm and Garden."

which shrivels and dissolves away under the influence of heat. Beneath this hard external epidermis composed of chitine we find the true skin, forming a deep, soft layer, and intimately connected with the external epidermis; the minute ducts of numerous small glands embedded in the true skin pass to the epidermis, entering the base of the external hairs. According to the age and progress of development of the insect, certain calcareous salts, colouring matters and fat are found to be added in varying proportions to the chitine of the outer integument, and it is this external epidermis which from time to time is cast or moulted off during the growth and transformation of the insect.

"The external skin of insects may be smooth and glossy in appearance, covered with raised, warty knobs, or clothed with hairs or scales.

"The body of a true insect, such as a beetle, a butterfly, or a caterpillar, is divided into three parts—viz. the *head*, consisting of a number of closely united segments, bearing on its lower or ventral surface the mouth, and upon its sides two large compound eyes. Upon its upper or dorsal surface, in many species of insects, are one, two, or three simple eyes, or *ocelli*, and a pair of feelers or horns, the *antennæ*. The second division of the insect's body is called the *thorax*, or chest region, and consists of three segments, which are either separate from each other or fused together. Each of these segments has a distinguishing name: the first, which joins the head, is called the *prothorax*, and bears the front or anterior pair of legs; the second is the *mesothorax*, and, in the case of a winged insect, carries, besides the pair of legs on the lower surface, a pair of wings upon the upper or dorsal surface; the third segment, called the *metathorax*, may also carry a pair of wings on its dorsal surface as well as the regulation pair of legs beneath.

"The third division of the insect's body is called the *abdomen*, and is composed of a series of segments varying in number. In the perfect or adult insect no legs are to be found upon the abdomen, but during the larval stage of the insect's life fleshy tubercles, the pro-legs, may be present. The six true legs of the insect are always placed upon the ventral surface of the three thoracic segments; while the pro-legs, which are only present on the larvæ, are in pairs upon the lower surface of the abdominal segments.



European Emperor Moth

"Old Lady" Moth at rest on tree-trunk

Male Stag Beetle

1. Maxillæ
2. Mandibles
3. Antennæ
4. Head
5. Thorax
6. Elytron
7. Leg

"Two kinds of eyes are peculiar to insects—viz. compound eyes and simple eyes or *ocelli*. The compound eye is generally large and conspicuous, divided up into numerous six-sided prisms closely united together. Each six-sided prism is called a facet, and is a perfectly transparent bi-convex lens. What the true function of the simple eyes may be is doubtful, but from their position and structure they probably are useful in judging the intensity and direction of the light, and possibly for close vision.

"There are three distinctive forms of mouth to be met with amongst insects: the sucking mouth, the piercing mouth, and the biting mouth. The parts of the mouth are divided into six articulated pieces, called respectively the upper-lip or *labrum*; the two pairs of jaws, called the *mandibles* and *maxillæ*; and the lower lip or *labium*. Both the maxillæ and labium have attached to them jointed appendages called *palpi*.

"The true legs of an insect consist of six to nine joints. The first joint, which attaches the leg to the ventral surface of the thorax, is called the *coxa*; the second joint, which is short, is the *trochanter*; this is followed by a large and frequently stoutly built joint, the *femur*; the next joint, often long and thin, is the *tibia*; and lastly, a series of short joints, one to five in number, called the *tarsus*, the terminal joint bearing a pair of claws or *ungues*."

The facts that all insects are capable of movement in a definite direction, and that they are conscious of pain, heat, cold, light, and darkness, prove the presence of a well-developed nervous system. This more or less elaborate nervous system consists of a double chain of nervous matter on the ventral surface of the body, joined together by intervening double swellings, and corresponding in function to the spinal cord and brain of the vertebrate animals. A pair of these closely united, swollen nerve masses are present in each segment of the insect's body from the head to the tail, and are called the *ganglia*. From these large nerve centres go forth branching nerves to supply the jaws, eyes, antennæ, wings, legs, feet, stings, and ovipositors with consciousness.

All true insects are incapable of breathing through their mouths, the act of respiration being accomplished by means of specially adapted apertures along the sides of the body. These

breathing pores are called *stigmata* or *spiracles*. Each spiracle is in the form of an oval slit, and consists of two openings—an inner one which is closed by a valve, and an external one protected by hairs. From the inner opening of the spiracles arise curious tubular structures, called *tracheæ*, which function as lungs, and branch in every direction through the body. The breathing pores or spiracles are found in different situations on different insects, though, as a rule, they are situated along the sides of the abdomen and thorax.

Although no regular system of blood-vessels is recognised in insects, as in the higher animals, organs of circulation exist. A large vessel, situated immediately under the dorsal integument, extends from near the apex of the abdomen to the right of the brain, at which end it is open. This dorsal vessel, or heart, contains a series of cavities—the ventricles—having openings on each side, and communicating with each other by a valve. The speed of circulation and number of pulsations of the dorsal vessel depend upon temperature, rising and falling with it, and almost ceasing at freezing-point. The blood is colourless, and contains white amœboid corpuscles analogous to those of the vertebrates.

CHAPTER X

THE COLEOPTERA: BEETLES

The Coleoptera comprises those insects which are popularly called Beetles. Their numbers are legion, and something like 150,000 species have been collected, of which a great proportion have been described. Considering the amount of attention which the Coleoptera have received, one might think that there was something unusually interesting about them; but this is not the case, and one can only suppose that the interest they have excited is due to the beauty of some of them, to the curious shape of many, and to the ease with which they may be preserved.

Beetles are very readily distinguished from all other insects. The upper pair of wings are always of the same hard texture as the other parts of the body; they never cross one over the other when the insect is at rest, but meet in a straight suture down the back, and cover the body more or less perfectly. They are sheaths, and act as coverings to the hind pair of large membranous wings which lie folded beneath them. The name Coleoptera is taken from this peculiarity (literally, "sheath-winged"), and the sheaths are called *elytra*. These elytra, when the beetle takes flight, open at right angles with the body and project straight out from it, remaining fixed in that position during flight, and do not beat the air or vibrate, the larger and membranous hind wings being the organs by which the beetle propels itself through the air. The parts of the mouth are generally well developed and strong, and are fashioned for purposes of mastication. All the Coleoptera undergo complete metamorphosis. The larva varies very greatly in form in different families; it is generally elongated, clothed with a tough skin, and furnished with six feet, but in some groups it is a footless maggot. In all its forms however, the coleopterous larva has a distinct head, and thus

may be distinguished from the often very similar larvæ of the *Diptera* or Two-winged Flies.

Although so diverse in form and habit, none of the Coleoptera display those wonderful social habits which are such a striking feature of the life of the ants, bees, and wasps; nor do they display the architectural ability of the *Hymenoptera*. Nevertheless, a large proportion are of considerable economic importance, acting as natural scavengers, burying dead animals beneath the surface of the soil, feeding upon and depositing their eggs in the body so interred; and also feeding upon all sorts of animal and vegetable garbage. Others, again, are anything but beneficial, attacking not only the growing crops of the farmer and market gardener, but taking toll of stored grain, flour, hides, furs, and timber.

The first tribe of the order Coleoptera, called the **Adephaga**, is distinguished from all others by the very characteristic adaptation of form to carnivorous and predaceous habits. The limbs are constructed for rapid locomotion, and the body for rapid movements; while the parts of the mouth are strongly developed. To this tribe belong the Tiger Beetles (*Cicindelidæ*), elegant and finely coloured beetles with large jaws, sharp and toothed mandibles, and long, slender legs. The Common Green Tiger Beetle is really a very handsome insect, wonderfully active and bold, and is carnivorous in its habits. The larva has all the desire for slaughter evinced by its parents, but its long body covered only with a thin skin, and its short legs, prevent it from giving chase to its prey; nevertheless, it has the means of obtaining victims without exposing itself to much risk. With the help of its short, thick, spiny legs the larva digs a hole in the ground, using its head as a kind of shovel to cast forth the earth, and in this way is formed a vertical tunnel, which curves at a certain depth so as to become a horizontal gallery. The larva has two curious fleshy tubercles and and curved hooks upon the very swollen fifth segment of its body, and if it wishes to remain set fast in its tunnel it sticks the back of its body against the sides and rests safely with the aid of its hooks. In this position it can poke its head out of the ground, and it closes the entrance of its tunnel and waits until some small insect, such as an ant, passes over. The top of the larva's head forms the floor of the cavity, and when an incautious insect steps upon it the Tiger larva lets go its hold and descends with sudden

and great precipitation. The unlucky victim at the same time falls down the hole, and is forthwith seized and devoured. When fully grown, the larva closes the orifice of its hole, within which it then undergoes its metamorphosis.

The Carabus Beetles are for the most part large, brilliantly coloured insects, and their peculiarly-shaped heads, long legs, and beautifully armoured bodies give them a handsome and somewhat fierce aspect. They may often be found concealed under stones or the fallen branches of trees, and in similar situations, while the common *Carabus auratus* is constantly seen running about the roads and fields in search of prey. This beetle is really of value to the farmer and gardener, for it destroys a number of soft-bodied insects which are harmful to various crops. It is of a beautiful golden-green colour, with russet-tinted antennæ and legs, and the elytra are decorated with three rounded, sculptured ribs. In France it goes by the name of "the Gardener," or "the Sempstress," though why the latter it is hard to say. The Carabus devours caterpillars and snails, and any unfortunate cockchafer that may bump against something in its flight and fall to the ground on its back is at once pounced upon, torn open, and devoured. The larva is of a shiny black colour, and during the daytime hides away under stones, or turfs, or in holes in the ground, coming forth to hunt its prey at night.

The Common Water Beetle (*Dytiscus marginalis*) lives in more or less stagnant ponds and slow-moving streams. It is provided with large wings, with which it can fly from one pond to another, and so is equally at home on land. It is formed like a regular land beetle, and is therefore obliged to come to the surface of the water every now and then in order to breathe, and a very simple arrangement enables it to obtain a fresh supply of air. The spiracles, or breathing organs, are situated on the upper part of the body, and are protected by the elytra, or wing cases, which fit the upper part and sides of the body, so that no water can get beneath them. When the insect wishes to breathe it floats to the top of the water, so that the upper part of the back projects above the surface; then the elytra are raised, expiration takes place, and a supply of fresh air is inspired; the wing cases are then shut down enclosing a supply of air, which the beetle can use while beneath the surface. The Dytiscus is carnivorous in its

habits, attacking all kinds of aquatic insects, tadpoles, and even small fish. The larva lives in the water, and is as rapacious and sanguinary in its habits as the adult.

The Great Water Beetle (*Hydrophilus piceus*), although sometimes attaining to nearly twice the size of the Dytiscus, is not nearly such a ferocious insect; indeed, for the most part it is a leaf-eater, although in the larval stage it will sometimes display a carnivorous habit. The most remarkable structural feature of this beetle is the presence in the female of some abdominal glands which produce a silky substance that covers the eggs with an impervious cocoon.

The family of the **Scarabæidæ** is, perhaps, the most interesting as well as the most numerous of the Coleoptera, and its members present remarkable distinctions in their habits, food, methods of life, and conformation. But although they vary so much amongst themselves, these beetles constitute a very natural and very characteristic assemblage. They possess antennæ which are short and inserted into a cavity underneath the lateral edges of the head, and which end in a club-shaped mass made up of several leaflets. The antennæ enable us to distinguish most of the Scarab Beetles at once. To this family belong the familiar Cockchafers, the Dung Beetles, the beautiful metallic Rose Beetles, and the Sacred Scarab Beetle of Egypt; and some members attain the largest size amongst insects.

The Cockchafer (*Melolontha vulgaris*) is also sometimes called the "May Bug," the latter name referring to the season when the perfect insect first appears. In some years vast numbers of these beetles appear, and they are just as scarce in others; and this is due to the long duration of the larval stage, which lasts for three years. Both larva and perfect insect cause considerable damage; the larva by attacking the roots of plants, and the beetle by devouring the young buds and tender foliage. The cockchafer is a common agricultural pest all over Europe, being found wherever the farming industry thrives, for agricultural operations favour these insects, as the larvæ cannot mature in undisturbed soil; so that the more the ground is ploughed and dressed, rendering it light and suitable for vegetation, the better it is for the cockchafer larvæ. Fortunately for the farmer and gardener, the rooks, gulls, lapwings, crows, magpies, and many other birds devour great

Male, larva, and female Water Beetles (*Dytiscus*)

The second leg (middle pair) of Dytiscus

Front leg of male Dytiscus Beetle

Comb-like antenna of Cockchafer, showing the delicate hairs and pits

The Palm Weevil

Great Hydrophilus Beetle

quantities of these grubs; and but for the senseless and wanton destruction of many insect-eating birds, Nature would provide a check on the immense increase of these insects, which from time to time cause such serious damage.

For a graphic description of the habits of the Sacred Scarab Beetle (*Scarabæus sacer*) we cannot go to a better authority than Monsieur Fabre, who so devotedly watched and described the habits of this insect. My only regret is that lack of space forbids my quoting the whole of his vivacious and delightful description:

"The edge of the beetle's head is large and flat, and armed with six angular teeth arranged in a semicircle. It is the tool for digging and dividing, the rake to lift or reject such vegetable fibres as are not nutritious, to seek out what is best, and rake it together. A choice is thus made, for these keen connoisseurs like one thing better than another—a somewhat careless choice, indeed, if the beetle alone be concerned, but one which is rigorously scrupulous if the maternal ball be in question, with its central hollow where the egg will hatch. Then every scrap of fibre is rejected, and only the quintessence of the stercoraceous matter is used to build the inner layer of the cell. Then, as soon as it is hatched the young larva finds in the walls of its dwelling a dainty food which strengthens digestion and enables it later to attack the coarse outer layers. For its own needs the beetle is less fastidious, contenting itself with a general selection.

"Provender being gathered, the next thing is to retire from the mêlée and carry it to a fitting place. Now we see some of the most characteristic habits of the Scarabæus. He sets out at once, embracing the ball with the long hind legs, whose talons, planted in the mass, serve as pivots—leans on the intermediary legs as pivots, and using as levers the flat of the toothed forefeet, which press the ground alternately, journeys backward with his load, the body bent, the head low, and the hinder part upraised. The hind feet, which are the chief organs in the mechanism, move continually, going and coming and changing the place where the talons are stuck in, to alter the axis of rotation, to keep the load balanced and advance by an alternate push right and left. Thus the ball comes in contact with the ground in every part of it, which gives it a perfect shape and lends consistency to the outer layer by a uniform pressure. Courage! it moves, it rolls, and

the journey's end will be reached, though not without trouble. Here is a first difficulty. The beetle has to cross a slope, and the heavy ball would naturally follow the incline, but for reasons best known to itself the insect prefers to cross this natural slope —an audacious plan, which one false step or a grain of sand to upset the balance, will defeat. The false step is made, the ball rolls to the bottom of the valley, and the insect, upset by the impetus of its load, staggers, gets again on its legs, and hastens to harness itself afresh. . . . The attempt is renewed and better managed at the difficult points; a nasty grass-root, which occasioned the previous tumbles, is prudently turned; we have almost got to the top. But gently—gently! The ascent is perilous, and a mere nothing may ruin all. A leg slips on a bit of smooth gravel, and ball and scavenger roll down together. The beetle begins all over again with tireless obstinacy. Ten times, twenty times, will it attempt that further ascent, until persistency vanquishes all obstacles, or until, better advised, it takes the level road."

Monsieur Fabre goes on to relate how two Scarabs may sometimes be seen pushing along the same ball of dung. At first he thought that this might be an association of the two sexes, "a couple about to set up house," but careful investigation showed this not to be the case, the second beetle really being a thief, who, under the pretence of giving a helping hand, is only awaiting a favourable chance to rob the rightful owner of his ball of dung. When a suitable spot has been found, the Scarab proceeds to excavate a banqueting chamber beneath the soil, which will hold himself and his precious ball. Once the hole is ready, the ball is lowered into it, and the beetle follows, first stopping up the mouth of the entrance with fragments of earth and sand, so that no one shall enter uninvited to share in the feast; though sometimes the would-be robber, who has been unable to walk off with the ball, is admitted. Then the beetle settles down to enjoy the fruits of its labours, and continues without intermission to feast upon the ball of dung until every particle has been consumed.

The Goliath Beetle well merits its name, for it is indeed a giant amongst insects, measuring 4 or 5 inches in length, and of considerable girth. It is an African insect, and specimens have been collected from the coast of Guinea and of Cape Palmas,

Sierra Leone, and the forests of Uganda, where the Goliath is said to be seen fluttering about the tops of trees in search of the flowers on which it feeds. Greatly prized by collectors on account of their unique size and handsome appearance, the Goliath Beetles, when first brought to Europe, fetched very high prices, as much as £50 having been given for a single specimen. Other rare and interesting beetles of great size are the Hercules Beetle (*Dynastes Hercules*), from Dominica (West Indies), the Elephant Beetle (*Megasoma elephas*), from Chiriqui, and the Rhinoceros Beetle (*Cœlosis bicornis*), which is of lesser size, but has the head and thorax adorned with formidable horns. In all cases it is the male beetle which is furnished with these remarkable horns, and they vary considerably in size in different specimens of the same species. Although at first one might imagine that these formidable-looking outgrowths were developed as weapons of offence, the general weight of evidence obtained from careful observation of these remarkable insects in their natural haunts all points to their being simply ornaments, for they are but little used for fighting. The fact that the males are very much larger than the females, and that the remarkable development of the horns is usually confined to them, suggests that some sexual reason exists for these extraordinary projections. The great development of the mandibles in the male Stag Beetle (*Lucanus cervus*), the largest of our British beetles, is another interesting example. The female beetles do not possess these large mandibles, and the structures are of ordinary proportions in them, being furnished with teeth which enable them to be used as leaf-cutters.

The Sexton Beetle (*Necrophorus vespillo*) is particularly interesting on account of its remarkable habits. When the dead body of a small animal or a bird remains on the ground in the open fields or woodland, the Sexton Beetles soon begin to collect around it in numbers, their purpose being not so much to feed upon the dead body as to bury it and deposit their eggs in it, so that a supply of nourishment may be secured for their offspring. They hollow out the ground beneath the body, and make a tolerably deep hole by throwing out the soil with their large legs; then the animal sinks down, and they cover it up with the earth which has collected around the margin of the pit. By dint of hard, incessant toil the beetles manage to bury a small animal in about

twenty-four hours; and then they begin to feed upon the body. The female speedily deposits her eggs in the corpse, and these soon become larvæ, and feed, like their parents, upon the putrid matter until they acquire their full size, when they quit the remains of the dead body, and make a cell at some depth below the surface of the earth, in which they undergo their metamorphosis. Although their habits appear unpleasant, the Sexton Beetles really render valuable service, acting as natural scavengers, as, by burying the bodies of small animals beneath the soil, they prevent the air from becoming tainted by the odours of decomposition, and at the same time enrich the earth.

The Devil's Coach-horse (*Staphylinus olens*) is a familiar black-beetle, which is often to be seen on country roads, and emits a very unpleasant smell. It is a carnivorous insect, and most astonishingly bold and impudent. When disturbed it does not attempt to run away, but stops in its progress and shows fight at once. It plants its feet firmly on the ground, cocks up its head and tail, snaps its sharp jaws in the most defiant manner, and sends forth its horrible smell. The larva somewhat resembles the adult insect in appearance, and is quite as pugnacious and carnivorous in its habits, hiding away during the daytime and coming forth at night to seek its prey. One member of the genus, the *Staphylinus maxillosus*, has very formidable jaws, and lives upon the bodies of dead animals; others, with very thin, long bodies, are common in damp woods, where they hunt their prey among the fallen leaves and decaying branches; while another species is found in hornets' nests, where it probably feeds upon the larvæ of those formidable wasps.

Some very remarkable **Staphylinidæ** are found in the nests of the termites of Brazil, and are distinguished by the enormous development of the abdomen, which is turned up so that it rests upon the back of the insect. The enormous distension of this part of the body is due to the fact that these beetles do not lay eggs, but produce living young—the only species of beetle which bring forth their progeny in this way. This remarkable discovery was first published in 1864 by Schiödte, who states that the hairs which cover parts of the abdomen are furnished with a secretion that is much liked by the termites. These curious and interesting beetles are about $\frac{1}{10}$ of an inch in length, and their abdomen is soft.

Goliath Beetle

Sacred Scarab Beetles

Rhinoceros Beetle

Hercules Beetle

Elephant Beetle

The Glow-worms are beetles belonging to the genus **Lampyris,** and it is the females that sparkle like little gems upon the grass stems and foliage on warm summer nights. The males have large wings and long elytra, but the females have only rudimentary wings and cannot fly. They are more numerous than the males, and the curious phosphorescent light which comes from the under part of their abdomen, and is under the control of the insect, is used to attract the males. The larvæ are highly developed, and resemble the females in appearance; they attack and devour snails and slugs.

The wonderful Fireflies of the West Indies and South America belong to the family **Elateridæ,** and are not true Glow-worms. The light is emitted from two rounded spots on the prothorax, which are covered with a thinner and paler horny coating than the rest of the integument. To this family also belong the Click Beetles or "Skip-jacks," as they are often called, which in their larval stage are only too well known to farmers and gardeners under the name of Wireworms, when they cause great damage to root crops.

The Weevils (**Curculionidæ**) are readily recognised by the long snout, which bears at its extremity the organs of the mouth, and the elbowed antennæ, features which give these insects a very characteristic appearance. Weevils abound in both temperate and tropical countries, and during their larval stage are often very destructive to trees, fruit, leaves, roots, and seeds. The *Calandra granaria,* for instance, is a small species common throughout Europe and having an evil notoriety for the devastation which it causes in granaries; while an allied species causes similar injury to stores of rice and maize in India and other tropical countries. Many of the Weevils are extremely small in size, but others belonging to the genera *Rhyncophorus* and *Macrochirus* attain to considerable proportions. These giant Weevils in their larval stage live in the stems of succulent plants and trees, such as palms, bananas, and sugar-cane. The Palm Weevil is a very handsome, warm black insect, about 2 inches in length, with a typical long snout and elbowed antennæ.

The **Longicorns,** or Long Horn Beetles, so called from the great length of their antennæ, are a very numerous tribe of beetles, distinguished for the grace and beauty of their shape and the

elegance of their colour and markings; many of them reach a great size, the *Titanus gigas*, of Cayenne and the Amazons, and the *Xixuthrus heros*, of the Fiji Islands, being amongst the largest known beetles, attaining 6 inches in length of body. The larvæ live either under the bark of trees or in the wood of the stem, while some feed on roots. Upwards of 8,000 species are known, the majority inhabiting the forest regions of the tropics.

The Ladybirds, with their dome-shaped bodies and bright spotted wing-cases, are familiar beetles needing no description here, for they are among the first insects with which I suppose every child becomes acquainted, if only by the old nursery rhyme, "Lady-bird, Lady-bird, fly away home! Your house is on fire, your children all flown." Nearly the whole family prey upon aphides or plant-lice, and in this way do good service in our gardens and in the hop fields.

CHAPTER XI

HYMENOPTERA: ANTS, BEES AND WASPS

To the order **Hymenoptera** belong the most interesting and intelligent of all insects. The late Lord Avebury considered that—"If we judge animals by their intelligence as evinced in their actions, it is not the gorilla and the chimpanzee, but the bee and, above all, the ant which approach nearest to man." Indeed, in the wonderfully ordered economy of their lives many of the social Hymenoptera surpass even man himself, for, as Tickner Edwards says in writing of the bees—"Perhaps tens of thousands of years before man had made fire, or chipped a flint into an axe-head, these winged nations had evolved a perfect plan of life, and solved social problems such as are only just beginning to cloud the horizon of human existence in the twentieth century. And they and their intricate communal polity have not passed away into dust, as the great human nations of bygone ages have done, and as those of the present day may be destined to do for all we can tell."

The order is a very extensive one; tens of thousands of species have been named or described, yet those still unknown must number even more. It includes the ants, bees, wasps, saw-flies, and ichneumon-flies; insects which normally possess four membranous wings, transparent and with comparatively few veins. The hind pair is always smaller than the first pair, and when in flight the hind-wings are locked to the fore-wings by a row of minute hooklets placed along part of the front margin, which cling fast to a groove or fold on the lower edge of the front pair. The abdomen is usually attached to the thorax by a slender waist or *petiole*, which may be very short, so that it is not observable unless the abdomen is deflected, as in the bees, or of most extraordinary length, as in many of the solitary wasps. The head is generally large, and bears three ocelli on the forehead, in addition to the great compound pair: the mouth is adapted both for biting

and sucking; and the female is provided with a conspicuous ovipositor, which in some families is modified into a sting, in others into a saw, or it may be adapted for piercing or boring.

The Ants have attracted attention from the earliest ages on account of their remarkable habits and intelligent ways; and, indeed, the more one studies these wonderful little creatures the more one is astonished and fascinated by the ordered economy of their social life, and the industry, resourcefulness, and intelligence of the "little people."

All ants are included in one great family, the **Formicidiæ,** which is, however, divided into several sub-families or groups, varying from one another in details of structure and ways of life. Ants as a whole possess curious triangular-shaped heads; the antennæ are bent, forming a jointed elbow; the mandibles are very strong and work freely apart from the mouth, which can be kept closed while the mandibles are used for biting or carrying; the pedicle which attaches the abdomen to the thorax varies in different groups; it may have either one or two nodes or knots upon it, and these curious knots are differently shaped according to the particular species of ant.

An ordinary community of ants consists of a vast number of workers; imperfect females, who are wingless; one or more queens or perfect females; and a certain number of winged males. In some nests there may be several kinds of workers, each kind having its own particular duties to perform. The queen ants, when they emerge from the cocoon, are winged, but after their nuptial flight they cast their wings and enter on a long life devoted entirely to laying eggs and populating the nest. The males appear in vast number in the nests in the mating season, but their life is of short duration, for after the marriage flight is over they soon perish.

It is a remarkable sight on a warm summer day to see the young winged queens and the male ants pouring out of the nests in countless numbers, rising like thin columns of smoke into the sunlit air, their gauzy wings gleaming with iridescent hues. When the flight is over the young queens that survive may be received into an old nest, or, with the aid of a small band of workers, start new colonies of their own.

The ant queen is lodged in a special chamber and attended

by a retinue of workers, whose duty it is to feed and clean her and to carry off the tiny, oval-shaped eggs as soon as they are deposited. The greatest care is taken of the eggs; they are kept at a uniform temperature, being carried off at once to another part of the nest should the chamber in which they are kept become too hot or too cold. The larvæ when hatched are weak, helpless grubs, entirely dependent on the workers, who make the most devoted nurses. They are kept in special nurseries, fed and cleaned, and on warm, sunny days carried out on to the top of the nest for an airing. But should rain threaten or any danger approach the little creatures are at once seized in the jaws of the watchful nurses and carried off to a place of safety within the nest.

When the larvæ are full grown they change to pupæ, usually spinning a silky, white cocoon in which to complete their metamorphosis. It is these oval cocoons which are collected and sold for feeding young pheasants and gold-fish, and commonly but wrongly called "ants' eggs." The workers pay the greatest attention to the cocoons, keeping them clean, arranging them in little heaps, and anxiously watching for the first signs that show that the little creatures within the cocoons have completed their metamorphosis and become perfect ants. When this time arrives the workers cut open the cocoons and help the new arrivals, which are at first very weak and feeble, to free themselves from their wrappings. At first the new-comers are fed and cared for by the workers, who lead them all over the nest and introduce them to their comrades; but in a short time they gain strength and take their place among the other worker ants belonging to the community.

The nests of ants always consist of a number of irregularly formed chambers connected by a network of winding galleries. In England these nests are for the most part formed below the ground, often at a considerable depth beneath the surface. These subterranean ant-cities are often supplemented by an ant-hill above ground, containing several apartments of different sizes connected with those below by numerous passages. The ant-hills vary according to the particular species of ant by which they are erected. The well-known Wood Ants (*Formica rufa*) form theirs of pine-needles and small fragments of stick, often erecting mounds 3 or 4 feet in height and 10 feet or more in

circumference; and although to all appearance the nest is but a medley of odds and ends piled up in a haphazard fashion, every one of those pine-needles and fragments has been truly and carefully laid in place by the skilful little builders. The rough-looking heap is in reality a model building, perfectly planned and carried out, and exactly adapted to the requirements and mode of life of the ant-people.

Not only are the Wood Ants proficient in building, they are road-makers too. From the ant-hill in various directions are well-defined tracks, traversed by the workers as they go about their tasks outside the confines of the nest. Up and down these roadways myriads of the little creatures are continually passing, all intent on important business, though what that business is it is not always easy to determine. It is quite evident, though, even to our eyes, that parties of ants are setting forth on foraging expeditions, some are making or mending the roads, some are wending their way homewards carrying fresh building materials to enlarge or repair the nest; now and again successful hunting parties may be seen returning to the nest dragging between them a large caterpillar, or each individual carrying a smaller victim in its jaws. While if we watch these restless little creatures carefully we shall notice here and there certain individuals that are plainly taking a holiday walking about amusing themselves and pausing by the way to exchange a few words with their friends and acquaintances, after the manner of human folk.

The little yellow Meadow Ant, *Lasius flavus*, and the common black Garden Ant, *L. niger*, throw up mounds of loose soil taken from the underground excavations, which serve to throw off the rain and prevent the subterranean chambers and galleries from being flooded; or the entrance to the nest may be simply under a stone, while the Garden Ant will sometimes take advantage of an inverted flower-pot as a means of protection. Species of the genus *Lasius* are very common in England. Although amongst the smallest of ants, they are wonderfully clever and courageous little creatures. When attacked by parties of marauding ants from other larger species they will boldly defend themselves, but will always retreat within their nests at the first favourable opportunity, and block the entrances of the galleries to prevent their foes from gaining admission.

L. fuliginosus, another species common in Britain, makes its dwelling in the hollows of old trees or decaying stumps of wood, forming the chambers and galleries with a sort of cardboard made from masticated wood-dust worked up with a viscid secretion of its salivary glands. This species, known as the "Jet Ant," is a shiny black, and much larger than the Garden Ant, *L. niger*. A tribe of these Jet Ants will often colonise a number of old trees in proximity to one another, and keep up a system of friendly intercommunication. If one habitation is attacked, the inmates will in some way signal to their allies, who at once dispatch detachments of workers to their assistance. By this means the Jet Ants are able to hold their own against all invaders, who are soon overwhelmed and routed by the combined armies.

Certain species of ant are particularly addicted to the habit of raiding the nests of other tribes and carrying off the larvæ and pupæ, either for use as food or to train up as servants to the colony. The Warrior Ant, *Formica sanguinea*, the only slave-making ant found in England, makes its nest in banks and is much like the large Wood Ant in appearance. Although perfectly able to do all the work of the colony without assistance, the Warrior Ants from time to time make organised raids on the nests of several other tribes, particularly on those of the little Black Ant, *Formica fusca*. Then, after a battle royal, in which the larger species usually come off conquerors, the warriors march back in triumph, each one carrying in its jaws a larva or pupa from the ravaged nest.

The captives are carefully tended by the Sanguinea until their metamorphosis is completed, and the stranger ants then act as willing slaves for the rest of their lives, and it is said are more skilful and hard-working than their masters.

The Amazon Ants (*Polyergus rufescens*) are a most extraordinary tribe of slave-makers. Dependence for ages on the help of slaves has rendered them incapable of working for themselves, and their mandibles have degenerated into mere toothless nippers, so that they are unable even to feed themselves. The slaves in an Amazon colony build and keep the nest in order, nurse the larvæ, and feed their owners, who would perish in the midst of plenty if no slaves were at hand to attend to their needs. The only thing the Amazon Ants can do for themselves is to fight. At this they are adepts; they are very courageous, and their strong nippers, which are

curved and sharply pointed, make them most formidable foes. When fighting, an Amazon seizes the head of its opponent between its mandibles and drives the points with great force into its brain.

It is a well-known fact that ants are extremely fond of the "honey-dew" excreted by aphides, and many species are in the habit of visiting the plants on which these troublesome pests swarm, to obtain a supply of their favourite food. Not only do the ants "milk" the aphides by gently stroking them with their antennæ, and so induce the insects to discharge the sugary fluid from two little tubes situated at the extremity of their bodies, but they guard them from the attacks of enemies, and even build sheds and covered ways for their protection. Some species, amongst which is the Little Yellow Ant (*L. flavus*), are regular miniature cattle farmers, keeping and tending large flocks or herds of these "ant cows" in the most intelligent and scientific manner. Should too many aphides swarm at one spot, and so make their food supply insufficient, the ants will remove some of their "cows" to fresh pastures. In late September and early October the ants carefully collect the eggs of a species of aphides from the daisy plants and keep them in the nest until the following spring. Then when the young aphides emerge, and the weather is warm enough, they are carried out of the nest by the worker ants and placed on the tender young daisy plants. There they are carefully guarded and regularly milked by the little farmers.

But aphides are not the only insects kept and tended by ants. Several species of beetles are habitually found living in the nests, where they are treated as honoured guests or pets of the colony. Some of these beetles are most grotesque and fantastic in appearance, while others are entirely dependent on the kindness and generosity of their hosts, who feed them from their mouths in the same way as they feed their larvæ. It is not quite evident why the ants harbour so many strangers within their gates, but it is probable that some of the beetles secrete some sweet fluid of which their hosts are fond, for the ants may be often seen licking the sides of their beetle-guests with every sign of pleasure and enjoyment. Besides these beetles, several insects belonging to other orders, including the larvæ of certain butterflies, and a small white crustacean allied to the wood-louse, are found living within ants' nests.

Very curious, too, are the relations existing between the large Wood Ants and two very minute species—the *Stenamma* and the *Solenopsis*. The Stenammas are found exclusively in the nests of the Wood Ants, and are treated by the rightful owners with the greatest kindness; the tiny creatures may often be seen frisking and gambolling about the larger ants like a lot of little dogs, and if for some reason the Wood Ants change their nests, the Stenammas always accompany them.

The Solenopsis, on the other hand, are not harboured willingly by the Wood Ants within their walls. These little robber ants make their home in the walls of the Wood Ants' nest, and constantly make raids upon their nurseries, carrying off the helpless larvæ as food. The workers give chase, but the audacious little robbers skip hastily back into their diminutive galleries with their booty, where, on account of their size, the enraged Wood Ants are not able to follow them.

Among the many interesting species of ants inhabiting tropical countries are the Sauba, or Umbrella Ants, of South America. In each nest there are no fewer than five different classes of individuals—queens, males, worker minors, which are small ordinary workers, and two types of major workers, which are very large ants with huge heads, hard and highly polished in one type and hairy in the other. What are the special duties of these curious, large-headed workers is not actually known. Bates, who studied the ways of the Sauba Ants very carefully, was never able to determine what part the major workers took in the work of the colony; they are, however, most formidable-looking creatures and may perhaps be useful in frightening off raiding ants from other tribes.

The small Sauba workers appear to do all the work. Parties consisting of several thousand ascend the trees and often almost strip them of their foliage, and in this way the ants do a considerable amount of damage to the cultivated coffee and orange trees. With their sharp, scissor-like jaws they snip the leaves into semicircular pieces about the size of a sixpence, and either at once carry the pieces back to the nest or throw them to the ground, when they are at once seized and borne off by another gang of workers. While they are at work regular streams of ants are constantly ascending and descending the tree, while an almost endless procession extends from the tree to the nest, each individual bearing

aloft in its jaws a tiny piece of leaf like a little umbrella, and from this they have gained their popular name of Umbrella Ants. The pieces of leaf are used to form a kind of thatch over the mounds which rise above the entrance to the subterranean nests, the thick layer of leaves being finally covered with a layer of earth which the workers bring up from some depth below the surface of the ground.

Besides stripping the young trees of their foliage, armies of Sauba Ants will sometimes raid houses at night and carry off the stores of farinha or mandioca meal, which is largely used as food by the artisan classes in Brazil. Bates noted that on these plundering expeditions there were always two classes of workers present—the small worker minors, who carried off the farinha grain by grain in their jaws, and the large major workers with the huge smooth heads, who apparently did nothing at all.

The Ecitons or Foraging Ants of Brazil are fierce, carnivorous insects, hunting their prey in large, well-organised armies. There are two types of workers—large-headed majors and small-headed minors; and in some species of Ecitons the large-headed workers have very peculiar jaws, so greatly lengthened as to make it quite impossible for them to do any work. These ants have no fixed nest, but wander about from place to place in large armies and form temporary resting-places, usually in hollow trees, where they cluster together like a swarm of bees. There are several species of Eciton Ants, some of which are quite blind; these shun the light, habitually moving along when on a hunting expedition under fallen leaves, and when obliged to cross an open space constructing temporary covered ways with granules of earth. In other species the visual organs are partially or fully developed.

The Driver Ants (*Dorylides*) of the Eastern hemisphere correspond in many ways to the Ecitons, which are peculiar to the New World. Like them, they are wanderers with no fixed place of abode, and in many species the workers and females are totally blind. In Western Africa the Driver Ants play the part of natural scavengers. When on the march they attack all creeping insects and small animals; and devour all dead animal matter that may come in their way. They will sometimes enter a house, and when they leave it and pass on their way the house is most effectively cleared of rats, mice, cockroaches, and vermin of all kinds.

The ferocious little Fire Ant of tropical America also occasionally invades houses in vast numbers, but they are much more harmful, for they devour the food and even destroy the clothing of the inhabitants. Their sting, too, is very painful, and the ants attack human beings and animals with the greatest fierceness.

The modes of life and the habits of the little ant-people are wonderfully varied, and often, to the human mind, most extraordinary. None, perhaps, are more peculiar in their ways than the Honey Ants, of the United States, Australia, and Mexico. It is the custom of this curious tribe to utilise certain members of the community as living receptacles for the food supply of the whole colony. These ants are filled with a kind of honey, the product of a gall on the leaves of the oak tree, so that they become enormously distended and are practically unable to move. They pass their time suspended from the roof of the store-room, visited from time to time by the ordinary workers, who pour fresh honey down the throat of these living honey-pots, or draw off supplies for the use of the community. Should one of these "honey-pots" meet with an accident and spill the honey, the workers gather round and lap it up; but if the honey-bearer dies the corpse is buried and the stored honey is not touched.

The Social Bees are quite as interesting in their ways as the ants, although their habits are not so diverse. Every hive or nest in the summer season normally contains a queen, a host of workers, and a certain number of males or drones. The old idea that the queen bee ruled over the hive, served by her willing and obedient subjects, has long been dispelled. The hive is in reality a republic, and the queen bee is merely the mother of the hive; she takes no part in the affairs of state, and her life is ordered and regulated by the worker bees, who are the true rulers of the colony.

The Honey-bee (*Apis mellifica*) is considered to be the highest type of bee; the wisdom of her ways, and the marvellous mechanism of her compact little body, so perfectly adapted to her life's work, have won the admiration of all thinking people. More books have, perhaps, been written upon the life and ways of this sober-looking little insect than upon all other creatures put together. It is impossible here to give more than a brief sketch of the life and character of this most fascinating of little insects, but for all who

are interested in the lore of the bee there are numerous delightful works by recognised authorities on the subject.

If we examine a bee-hive in the early days of the year, when winter is giving place to spring, we shall find that it contains a queen-mother and a certain number of workers, the survivors of the late broods of the previous year, who are just beginning to bestir themselves and awaken from the torpid condition in which they have passed the cold winter months. Bees do not hibernate in the true sense of the word; they cluster closely together in the centre of the hive with their precious queen-mother in their midst, and take food at intervals all through the winter, although only just enough to keep life within them; and whenever the sun shines warmly for a few hours they leave the hive for a short, cleansing flight. As soon as spring sets in they rouse themselves and begin to put the hive in order for the year's work: some leave the hive to fetch supplies of water, from the nearest stream or the dewdrops on the grasses—for water is absolutely necessary for the work of the hive at all its stages; combs are examined and repaired; and the dead bodies of the bees who have died during the winter are carried out of the hive. The bees now take advantage of every hour of sunshine to send forth foraging parties to seek pollen and nectar to replenish their diminished stores; the comb-builders set to work to build new combs; brood cells are prepared, and the queen lays the first few eggs of the year in them. Day by day as spring advances the bees grow more active, and soon the hive is humming with life.

In the beginning of the season the queen-mother lays but a few eggs each day, but as spring advances and the combs are being well filled with honey and pollen the number is increased, and in the height of the honey season a healthy queen may lay as many as 3,000 eggs a day. The number of eggs laid is regulated according to the requirements of the colony; when work is plentiful, and many labourers needed, the workers keep the queen steadily at her task; but should the weather become cold and wet, so that the bees are not able to leave the hive to fetch provision, egg-laying at once decreases or stops altogether.

The eggs hatch as helpless, legless grubs, entirely dependent on the workers, who feed them from their mouths, at first with "bee-milk," a thick white fluid composed of honey and pollen

partially digested by the worker bees, and afterwards with rations of pollen and honey. When fully fed the larva spins a silky cocoon in which it changes to a pupa, and its cell is sealed up by the workers with a cap of wax mixed with pollen; then, when it has completed its metamorphosis, the perfect bee bites its way through the cap of its cell, and in a short time is ready to take its place among the workers of the hive. The whole process from the laying of the egg to the emergence of the perfect insect from its cocoon takes about three weeks.

Towards the middle of April, if all is going well with the colony, a certain number of larger brood cells are prepared, and in these the queen deposits eggs which in due time will produce drones, or male bees. Not only can the queen regulate the number of eggs she lays, but the *kind* of egg laid is also under her control. In this matter, however, the queen is not allowed to use her own judgment; all her proceedings are directed by the workers. They lead her to the cells prepared for drones or workers, as the case may be, and she obediently deposits the right kind of egg in each.

As the drones begin to make their appearance in the hive the workers may decide to build a few royal cells. These are much larger than the ordinary cells, and in shape and size somewhat resemble an acorn-cup. Five or six cells are usually made and hung mouth downwards, either in the middle or at the side of the central brood combs. It is not certain whether the queen deposits the eggs in the royal cells herself, or whether they are transferred there from the common cells by the attendant workers; but the latter is most probably the case, as the mere sight of a royal cell is enough to rouse the queen to fury. The egg placed in a royal cell is actually the same as those from which workers are produced, but the resulting larva receives different and more generous treatment. Throughout the whole of its larval stage it is plied with the rich bee-milk which is only given to the common larva when it is first hatched. If by some mischance a hive is deprived of its queen, and no royal larvæ are available, the workers are able to rear a common grub as a queen, provided it is less than three days old, and thus young enough to respond to the change of treatment. When fully fed the royal larva is closed up in its cell by the workers, but instead of spinning a complete cocoon as the worker and the male larvæ do, it only encloses the head and upper

part of its body in a kind of shroud or wrapping. On completing its metamorphosis a young princess is not allowed to leave its cell, but is kept close prisoner by the workers, who pass food into the cell through a small hole in the waxen cap.

Only one queen can live in a hive at a time; and when, from the shrill piping of the imprisoned princess, the old queen knows she has a rival in the field, she grows greatly excited, and endeavours to reach the cell so that she may tear it open and kill the intruder. But this the workers will not allow; they bar her way, and beat her with scant ceremony should she resist their will. If the stock is a large and prosperous one, and the reigning queen-mother still in her prime, she will be allowed to go off with a swarm and start a new colony; but should the queen be old, and almost past egg-laying, the workers will ruthlessly put her to death. An old, useless queen is never allowed to live, but the workers never use their stings upon her; they crowd round her, pressing closer and closer until the breath is squeezed out of her body, and she is practically hugged to death.

When the swarm has departed, the young queen is liberated; and should there be any other royal cells in the hive, she at once tries to destroy them; but the workers mount guard over the remaining royal cells, and push and hustle the angry young queen away from their vicinity. She is treated by the whole colony as a creature of no importance; no one attends to her or offers her food; she is obliged to help herself from the open pollen tubs and honey cells in common with the workers of the hive. But this state of affairs does not continue for long; in a few days' time the young queen leaves the hive on her nuptial flight, and on her return she is received by the bees with every mark of delight and affection. She will not, however, settle down to her work while there are rivals in the hive, and for this once the workers allow her to have her way; they stand aside while the newly installed queen tears open the royal cells, and with a thrust of her long, curved ovipositor stabs every inmate to death. A queen bee may live until she is four or five years old, but she is rarely allowed to do so by the ruling workers. After two years her power of egg-laying usually begins to decrease, and as soon as this becomes evident she is put to death.

The queen bee in appearance is very much like a worker, but

her abdomen is larger and longer, and ends in a blunt point; her sting, or ovipositor, is long and curved, while the worker's is short and quite straight; the jaws and tongue, too, are differently formed, and she has not the remarkable appliances which fit the worker bee for her labours.

The tongue, as it is usually called, of the worker bee is a remarkable structure, consisting of six or seven separate parts which fit perfectly together lengthwise, forming, as it were, a tube within a tube. The central part is longer than the rest, and ends in a hairy spatula with which the bee laps up small quantities of fluid; but when she rifles a deep flower cup of its nectar the sweet fluid is drawn up the trunk with a pump-like action by the aid of strong tongue muscles. As the nectar passes through the mouth to the honey-sac, or first stomach, of the bee it is mingled automatically with a minute quantity of an acid secretion from two glands having a common opening at the root of the tongue; and thus it undergoes the first process of conversion into honey. When the honey is to be used as brood-food it is allowed to pass through a valve into the lower or second stomach, where, combined with pollen, it undergoes a process of digestion, converting it into a substance called "chyle," and this, when regurgitated by the nursing bees, is acted upon by yet other glands situated in the mouth, which finally change it into the "bee milk" given to larvæ, queen, and in smaller quantities to the drones.

On almost every joint of her six legs the worker bee has a tuft of stiff bristles, while her hind legs are provided with a perfect little curry-comb which is used for combing out the pollen dust from the hairs that clothe her body. The thigh of each hind leg is broadened and hollowed out and set with rows of transverse bristles, called the "pollen basket." In this the bee packs the pollen she has collected, after moistening it and rolling it into a ball.

The jaws of the worker are strong and smooth, with a sharp cutting edge, whereas the queen's have a notched edge. The sting of the worker consists of three separate blades with a barbed edge, one being broader than the others and furnished with a beaded edge on each side, while the two slender needle-like lances are grooved longitudinally. The beaded edges of the central blade, called the "director," fit perfectly into these grooves, and

the two needles slide up and down upon the director with the greatest ease, but cannot be pulled asunder. The sting is connected with special poison-glands, and as the bee thrusts her dart into a victim the poison flows along a channel between the needles and the director, drenching the blades with the fluid, rendering this three-bladed sword the most deadly of insect weapons.

The wax glands, six in number, are situated in the abdomen of the worker, and when the wax is formed it passes out between the segments on the under surface in the shape of delicate white wafers. Heat, as well as a generous supply of food, is necessary for its formation, and the bees when manufacturing the wax for the combs, after absorbing a quantity of sweet syrup, cluster closely together in the centre, the warmest place of the hive.

The drone is a larger, bulkier insect than the worker bee, but is her inferior in every way. His brain is imperfectly developed. He has no pollen baskets, no wax-secreting organs, and, of course, no sting. He is not provided with the brushes, combs, and wax-nippers possessed by the worker, so is quite incapable of working even if he would, while his tongue is too short to enable him to gather nectar from the flowers. The drone is, in fact, entirely dependent upon the worker for his livelihood; he consumes a large proportion of the honey and pollen set apart for the general use of the hive, besides being fed with bee-milk by the workers. He is tolerated by the community just so long as he is necessary. While there is any likelihood of a young queen requiring a mate the drone is allowed to go his way and take his fill of the provisions stored by the industrious workers; but when summer is on the wane he is no longer needed, and with sudden but organised ferocity the bees arise and drive him from their midst.

The workers do not sting the drones to death, as is commonly supposed; they drive them or drag them from the hive, after nipping through one wing so that they will not be able to fly back again, and every drone larva and pupa is torn from its cell and thrown over the edge of the alighting board. There is stern reason in this general massacre of the drones, for in the autumn and winter, when nectar and pollen are no longer to be had, the stores in the hive must be economised. All will be needed to feed those workers who, with the queen, will live through the winter to start the work of the colony in the following season.

Solitary Wasps

Ection and Wood Ants

Ichneumon Flies

Queen, Worker, and Drone Hive Bees

Humble Bees and Purple-winged Carpenter Bee

The genera *Bombus* and *Melipona* are also social in their habits. The genus *Bombus*, of which there are several species, includes the well-known Bumble, or Humble, Bees. They differ in many ways from the Hive Bees (*Apis*). The colony lasts for a season only, none of the workers surviving the winter. The young fertilised queens hibernate under moss or litter during the cold months of the year, and each one in the ensuing spring starts a new colony by herself. The nest may be made in a hole in the ground or under a heap of moss. The queen constructs a few waxen cells, in which she places several eggs, after having first stored the cells with a cake of honey and pollen. Quite unaided, she continues to build cells, lay eggs, and feed the larvæ as they emerge, until the first batch of workers have completed their metamorphosis and are ready to assist her. These workers do not differ structurally from the queen to the same degree as hive bees do; they are more or less imperfect females, and to a certain extent are often capable of supplementing the queen in egg-laying. As the colony increases the queen confines herself to egg-laying, the workers building the cells, attending to the larvæ, and fetching provisions. The nest of a Bumble Bee is not so well planned or so orderly in appearance as a colony of Hive Bees. The cells are of different shapes and sizes. Brood cells are never used twice for rearing larvæ; fresh cells are built on the ruins of the old ones, or some may be used for storing honey and pollen. An average colony of Bumble Bees in the autumn contains about 120 individuals; of these 25 may be females, 36 males, and the rest workers; but a prosperous colony may number between 300 and 400.

Living in the nests of Bombus, and on friendly terms with the rightful inmates, may often be found a certain number of bees belonging to the genus *Psithyrus*. In appearance the Psithyrus resemble their hosts, but their hind legs are not formed for carrying pollen, and they take no part in the work of the colony beyond, in some cases, constructing a few cells in which to deposit their eggs, the larvæ of these parasitic or commensal bees being brought up by the accommodating Bombus. There are no workers amongst these curious bees—only males and females; and, strangely enough, the Bombus never seems to object to the presence of the Psithyrus in the nest, although, as the bees of the last-named genus do no

work and consume a very large proportion of the provisions, they seriously affect the prosperity of the community.

The genus *Melipona* includes some of the smallest species of bees, some being so minute that they are commonly called "Mosquito Bees." These little bees inhabit most tropical countries and sometimes form enormous colonies; but it is not known whether these colonies contain one or several queens. These bees are also called "Stingless Bees"; but although it is true they do not sting, the term "stingless" is hardly correct, for, as a matter of fact, they do possess all the essential elements of the sting, though the lancet portion is undeveloped. The genus *Melipona* now includes the *Trigona* or *Tetragona*, of which the little *Trigona carbonaria* of Australia does not measure more than $\frac{3}{16}$ of an inch in length.

The Solitary Bees include a number of genera showing considerable diversity in their habits: many bore holes in decayed wood, such as old tree-trunks or wooden posts; others burrow in the ground or take advantage of burrows already formed by other creatures; and while some bees select loose, sandy soil for their excavations, others tunnel into stiff clayey soil, and the situation chosen may be on the ground or in the face of a sloping bank or cliff. Some species make their nests in the stems of plants such as brambles and briers, from which they remove the pith; but whatever the situation and material chosen, the Solitary Bee proceeds in much the same manner in the formation of her nest —i.e. the cell is first excavated, then provisioned with a cake of honey and pollen, and an egg laid on the top of it; the bee next closes the cell and leaves it. The larva on hatching from the egg consumes the provisions provided for it, and when fully fed spins a cocoon and changes to a pupa within it. In this state, if late in the season, it usually remains until the following year, when it emerges as a perfect insect, seeks a mate, and provides for the continuance of its species according to the custom of its family.

To the genera *Andrena* and *Halictus* belong the greater number of species inhabiting Britain. The Halictus are very small bees, and are particularly interesting in forming a link, as it were, between the social and solitary orders. They form large colonies, all the individuals combining to excavate a long, central gallery

in the earth, which ramifies into numerous branches, each one ending in a group of cells. The principal gallery, with its single entrance, is common to all; but the cells are formed and stored by separate individuals.

The *Andrena* much resemble the honey-bees, but they are smaller insects. They usually live in colonies, but each bee works entirely alone, and they have no common entrance to their burrows. The tunnels are formed side by side in sandy soil, but a colony will often select a garden path for its excavations.

The Great Violet Carpenter Bee, *Xylocopa violacea*, and the Mason Bee, *Chalicodoma muraria*, are extremely interesting solitary species. The former, which is not uncommon in the south of France, may be known by its velvety black body and violet-coloured wings. It bores into dry wood, forming a shaft a foot or more in depth, giving access to three or four parallel galleries. These galleries are divided into a number of cells with partitions made from the excavated sawdust mixed into a paste with saliva, and in each cell the bee deposits an egg after having provisioned it in the usual manner. The Mason Bee, which is also found in the South of France, builds its nest of earth and gravel, worked up with a secretion of its salivary glands into a kind of cement which sets as hard as stone. Each nest contains eight or nine cells, and a final layer of mortar is plastered over the whole so that it looks like a mass of dried mud about the size and shape of an egg.

Many species of *Osmia*, a genus allied to Chalicodoma, are in the habit of making their nests in curious places; some are fond of clearing out the straws in the thatch on old cottages to form their galleries; others take possession of empty snail shells, and some have even been known to construct their nests in the lock of a door.

The Leaf-cutting Bees, *Megachile*, are often seen at work in the rose garden cutting small neat pieces from the leaves with which to line the interior of their nests. These bees usually avail themselves of a burrow in the ground made by a worm or an insect, or they may fashion their tunnels for themselves. Their nests are often found, too, in old dry logs and gate-posts. Each little cell, when finished, is about the size and shape of a thimble, the insect deftly fitting the pieces of leaf, one overlapping the other, with her legs and jaws. The thimble-like cell, when completed

and stored, is closed with a lid composed of three or four circular pieces of leaf which exactly fit the open end; and five to seven cells are usually placed in a row, the rounded end of one fitting into the top of another. The leaves of the hornbeam, privet, and poplar are used by other species of *Megachile* in the formation of their cells.

The habits of the Social Wasps, *Vespidæ*, resemble those of the bumble bees in many ways. Each colony contains a queen or perfect female, a quantity of workers or imperfect females, and a certain number of males or drones. Each colony is founded by a queen wasp which has passed the winter in a state of hibernation. She builds a few cells in a suitable hole in the ground, or in a bank; in each of these she deposits an egg, and when the larvæ hatch she supplies them with food. She continues to build cells, lay eggs, and attend to the young alone, until the first batch of workers arrive to help her.

Wasps' nests are beautifully regular structures. The cells are hexagonal in form, and are placed side by side to form combs. In each comb is only a single row of cells, which open downwards. The first comb, made by the queen wasp, is suspended from the roof of the hollow in which the nest is situated, and each succeeding comb is attached to the one above it by three or four short pillars. The material used for making the combs is a kind of paper, or cardboard, made from wood-pulp, and manufactured by the wasps from fibres of dry wood, which they scrape from an old stump or paling, and chew until they are reduced to a pulpy mass. The whole of the nest is enveloped in a thick paper covering which is enlarged from time to time as fresh combs are added.

There is, however, a good deal of variety in the nests made by different species of wasps. Some are very solidly constructed, others made of the most delicate paper; some are composed of tier upon tier of combs, others consist of a single comb only. They vary in size, too, from the tiny nests no bigger than a small apple made by certain species, to huge nests measuring several feet or even yards in length, constructed by wasps found in China and India. Many species of wasp build in a hollow tree, while others suspend their paper structures from the branches of trees or even under the eaves of houses. The Hornet, *Vespa crabro*, is

addicted to this habit, and will frequently take possession of holes made by sparrows in thatched roofs.

The food of wasps, both in the larval and perfect state, consists partly of honey and fruit pulp, and partly of animal matter; the latter normally consists of insects, usually flies; while the Hornet is said to prey upon the honey bee.

Although many people are very much afraid of wasps, the insects are not nearly so ferocious as is generally supposed. They rarely if ever sting, unless they are interfered with, and when flying about are perfectly harmless; even the formidable-looking Hornet is, as a rule, quite peaceably disposed, and unless annoyed or frightened will seldom use its sting. But wasps are very courageous, and will fiercely attack anyone who molests them while they are at work, and will defend their nests against all comers.

The Solitary Wasps, or *Fossorial Hymenoptera*, like the solitary bees, construct cells for the protection of their eggs either in burrows in the ground, in the stems of plants, in old walls, or decayed wood; while some few make little nests of clay, and certain species are parasitic in the nests of bees. There are a vast number of species, and the insects are, as a rule, exceedingly wasp-like, although smaller than the true wasps. Their intelligence, industry, and remarkable habits attracted the attention of philosophers more than two thousand years ago. These little creatures can learn nothing from example, as the social insects do, yet each one knows instinctively how best to provide for its offspring, which in the majority of cases it will never see.

One of the commonest and best-known species is the Wall Wasp, *Odynerus parietum*, which in June and July may be seen searching over sunny walls. With its strong mandibles it excavates holes in the mortar 3 or 4 inches deep, and with the material it has removed the insect forms a projecting passage-way with the end turned downwards, through which it enters and leaves the nest. Having finished these operations to her satisfaction, the Odynerus starts off on a hunting expedition, her prey consisting exclusively of small caterpillars; having found a victim, she stings it and carries it off to the nest, where she carefully packs it away, curled up in the form of a ring. She repeats this performance until she has a little pile of caterpillars arranged one on the top of another in the nest, and on this she

deposits an egg and closes the cell, her last care being to destroy the projecting tunnel and so hide the entrance to the nest. One of the most remarkable facts relating to this little wasp is that she does not kill, but merely paralyses, her victims ; this, of course, prevents decomposition, and the larva on emerging from the egg finds a supply of perfectly fresh food awaiting it.

Each family of Solitary Wasps has its own idea as to the best food to provide for its progeny, and preys on a particular kind of insect ; some choose beetles, some flies, others caterpillars, aphides, species of Orthoptera or bees, while some store spiders in their nests instead of insects. In almost every case the victims are not killed outright but only rendered helpless, although whether this is really necessary for the larva's welfare has been much disputed, some authorities holding that the little creature flourishes just as well if by some mischance the victims have been killed ; but the generally accepted theory is that fresh meat is necessary for its perfect development.

There are no workers among the Solitary Wasps, only males and females occur, and in those families which are parasitic in the nests of bumble bees the females are wingless. The Fossorial Hymenoptera are themselves subject to the attacks of other parasitic insects which lay their eggs in the cells excavated and stored by the industrious wasps, the result being that the rightful owner of the cell is either starved through the supply of food being devoured by the parasites, or is itself devoured by the intruders.

Saw-flies are common insects in the field, wood, and garden, but they are so unobtrusive in their habits and appearance that they are not very generally known. Nevertheless, they are an important family of insects, and in the larval stage are exceedingly destructive to fruit, vegetable and various other crops. The female Saw-fly is armed with a remarkable ovipositor in the form of a double saw. Each tooth of the saw is itself serrated, making the saw a perfect instrument for cutting and rasping. The saw is used for making incisions in the leaves and stems of plants, and in these the female deposits her eggs. The Saw-fly larvæ resemble the caterpillars of the Lepidoptera, but may be readily distinguished by their greater number of legs, Saw-fly larvæ having from eighteen to twenty-two. They are exceedingly voracious,

and so do a great deal of harm to the plants on which they feed. Some live inside fruits ; others in the stems of plants ; while some roll themselves up in leaves or mine between the tissues

The Gall-flies, *Cynipidæ*, are minute insects, usually black or very dark in colour. More than forty species attack the oak, causing galls (among which is the familiar oak-apple) to form ; and the "bedeguar" or rose-gall is also caused by the agency of one of these little insects. The female Gall-fly pierces the tissues of the plant with her ovipositor, and in the wound inserts an egg. As the resulting larva feeds within the plant the curious swelling or gall forms round it, although the exact reason for this development is not known.

The Ichneumon Flies, of which nearly six thousand species have been described, are parasitic in the larval stage on the larvæ of Lepidoptera, and in this way render good service in helping to keep numerous insect pests in check. Most species live inside the bodies of their victims and feed on the fatty tissues without actually killing their hosts ; but the caterpillars become so weakened that they die on changing to pupæ, and the Ichneumon larvæ then issue from within and spin their tiny yellow cocoons outside the pupa cases. It is a common sight to see the pupæ of the cabbage white butterfly entirely covered by the cocoons of the parasite. The eggs are laid by the female on the outside of the skin, in some cases, and the larvæ on hatching bore their way under the skin of the caterpillar. Other species of Ichneumon pierce the skin of their victim with the ovipositor and lay their eggs beneath it ; and in some species the larvæ are parasitic externally. Although the Ichneumon Flies chiefly attack the larvæ of Lepidoptera, other insects and spiders fall victims to certain species.

CHAPTER XII

DIPTERA, ORTHOPTERA, HEMIPTERA AND NEUROPTERA

THE **Diptera,** or Two-winged Flies, are a very important group of insects, inasmuch as many of them are the transmitting agents of more or less serious, often fatal, diseases to man and to various domestic animals. They may be defined as insects with a perfect metamorphosis, a sucking mouth, and only two membranous wings, which are naked or more or less hairy, the hind wings being represented by a pair of small knobbed organs called *halteres* or "balancers." The mouth parts are highly developed, and may be formed for suction or for piercing, while in some the mouth parts are rudimentary in the adult stage. The head is very freely attached to the front of the thorax by a short and usually slender neck, which renders it freely movable. The compound eyes are generally large, often covering nearly the whole upper surface of the head, leaving only a small triangular space on the top for the three simple eyes, or ocelli, which are generally present, and another small space in front for the antennæ, which vary considerably in size, form, and structure. The eyes are as a rule larger in the males than in the females, and in the former often meet in the middle line on the head, while in the latter they are separated by a narrow band. The larvæ are footless grubs or maggots, generally with a soft body, but sometimes leathery, or even horny In several species the larvæ are hatched within the body of the mother, and in one whole group they are not only hatched but retained and nourished in the egg-passages until they are ready to pass into the pupa state.

Economically considered, the Diptera may be said to be both useful and harmful insects, for while great numbers act as scavengers, and a few as pollen carriers among the flowers, others ravage various crops, and, as already stated, are the carriers of disease. How truly appalling is their work as disseminators of disease we begin to realise when we come to consider such tropical

diseases as sleeping sickness and malaria in man. In the west of Uganda, since sleeping sickness was first noticed in 1901, more than 200,000 people have died of it. Of the 300,000 natives who inhabited the shores of the beautiful Victoria Nyanza, fewer than 100,000 remain, the rest having perished from this terrible disease. In every case sleeping sickness has been transmitted from one victim to another by the bite of a dipterous fly, the Tsetse Fly, or *Glossina palpalis*. Malaria and yellow fever are diseases which can only be transmitted from man to man through the bite of certain mosquitoes or gnats; while rinderpest, nagana, surra, gall-sickness, diseases of cattle, horses, mules, and camels in the tropics, are all transmitted to those animals through the agency of biting flies.[1]

The Mosquito passes the larval and active pupa stages of its life in stagnant pools and collections of water. As a larva it rises tail first to the surface to breathe, sticking out through the surface film of water its curious breathing-tube which is placed at the end of the body, and at almost right-angles to the tail. In the pupa stage it rises head-first to the surface, the respiratory apparatus of two short tubes now appearing on the back of the insect. As it is impossible for the Mosquito during these stages of its life to breathe except by rising to the surface of the water to take in a fresh supply of air, this is the period of its existence when it is most easily destroyed; and this is successfully accomplished by pouring any crude oil on the water infested by Mosquito larvæ and pupæ, so as to form a perfect unbroken film of oil over the whole surface, through which the insects find it impossible to thrust their breathing-tubes, and consequently quickly drown.

The Common House-Fly, after feasting upon all sorts of unspeakable filth and garbage, so that the hairs which clothe its feet, legs, head, and body have become laden with disease germs, enters the house and at once walks over any food that may be exposed, falling into the milk as likely as not, and contaminating everything it touches. During the warm summer days every precaution should be taken to prevent flies from entering rooms or settling upon food, while all house refuse likely to harbour these pests in their larval stage should be promptly destroyed.

[1] *See* the author's lecture on "The Economic Importance of a Study of Insect Life," vol. lvi., p. 688, "Journal of Royal Society of Arts."

The Gad Flies (*Tabanidæ*) are most objectionable on account of their biting habits, settling upon horses and cattle and sucking their blood. The mouth is armed with a sharp, lancet-like piercing organ, which inflicts a very painful and often dangerous wound, for these insects are undoubtedly responsible for the distribution of various cattle diseases, including anthrax.

Turning from those Diptera which are transmitting agents of disease to man and domestic animals, to those which ravage the crops, we find them to be quite as numerous. The Hessian Fly, and the Wheat Midge, or "Red Maggot," in the larval stage cause serious injury to wheat. Whole acres of grass-land and corn are destroyed annually by the larvæ of the Crane Fly, or "Daddy Long-legs" (*Tipula*), which burrow into the soil and attack the roots. These brownish-grey-coloured, cylindrical-bodied larvæ are popularly called "Leather-jackets," on account of their tough skins, and measure about 1½ inches in length when full grown. They also attack the roots of garden crops, such as cabbage and lettuce, causing considerable injury and loss. The Cabbage Fly, the Onion Fly, the Carrot Fly, and the Celery Fly, as their popular names denote, are all destructive to various crops.

The Hover Flies, or Breeze Flies (*Syrphidæ*), are a large and important group of handsome insects. They delight in warm, sunny weather, when they may be seen hovering and darting from flower to flower. In the genus *Syrphus*, which is typical of this group, the female deposits her eggs on leaves that are infested with aphides or plant lice, and the larvæ, on emerging, at once begin to devour the aphides, and destroy large numbers of them. In this way they do good service, and are among the few Diptera that can be said to be useful to mankind.

The **Hemiptera** are a very interesting Order of insects, which includes the Aphides or Plant Lice, the Bugs, the Lantern Flies, Cicadas, Water Scorpions, and Scale Insects. The Hemiptera are divided into two well-defined sub-orders: (1) the *Homoptera*, which includes the Cicadas, Aphides, Lantern Flies, and Scale Insects; and (2) the *Heteroptera*, or Bugs, Water Scorpions, etc. All undergo an incomplete metamorphosis, that is to say there is only a very slight difference between the larva, pupa, and perfect insect. The larva, which more or less resembles the perfect insect, lasts its skin a number of times. After one of these moults,

rudiments of the wings are seen, and the active pupal stage is reached. In due course the pupa casts its skin, and the adult, with fully developed wings, appears. The mouth is converted into a suctorial apparatus, slender and pointed for piercing the tissues of plants or, in the carnivorous forms, the skin of their prey. Four wings are generally present, and compound eyes of moderate size. They have a world-wide distribution, though they are most numerous and attain their largest size, most curious forms and brightest colours in the tropics.

The Shield Bugs live upon plants, trees and shrubs, feeding on the juices which they suck out of the soft tissues by the aid of their slender beaks. One of the best known is the Red-legged Bug (*Tropicoris rufipes*), which measures about ⅜ inch in length. The Colewort Bug (*Strachia oleracia*) is of a blue or greenish colour, variegated in the female with red and in the male with white markings, and is to be found on wild and cultivated cruciferous plants.

The **Gerridæ,** in their habits, may be said to link the Land Bugs with the Water Bugs, and during the summer months may be seen running actively over the surface of every pond and slow-moving stream. These insects have boat-shaped bodies, and the typical forms, such as the Pond Skater (*Gerris lacustris*), which frequent most ponds and streams, literally row themselves along the surface of the water by means of their long legs, their power of floating being aided by a coating of hair which covers the lower surface of the body and carries with it a supply of air. They chase and feed upon other insects.

The **Nepidæ,** or Water Scorpions, are rather sluggish in their movements, and creep about in a cautious way at the bottom of ponds and slow-moving streams. The front legs of these insects are completely modified as instruments for the capture of living prey; they are strong, pointed, minus the usual small claws, and can be folded back like a clasp-knife; indeed, in their shape, and the manner in which they are used, they closely resemble the fore-legs of the curious Praying Insect, or Mantis, which belongs to the Orthoptera. The Common Water Scorpion (*Nepa cinerea*) is about 1 inch long, and has an oblong, flat body, terminated by a pair of tail-like organs which, when put together, form a long, slender breathing tube. The Water Stick Insect (*Ranatra linearis*)

resembles the preceding insect in the form of the front legs, antennæ and air-tube, but has a long, slender, stick-like body.

The Cicadas (*Cicadidæ*) form the first family of the sub-order **Homoptera**, and are very interesting insects, attaining to their greatest size and number in tropical countries. Many are very handsome insects, with beautifully coloured wings, of which the front pair are always very much the larger. The head is large, rather square in front, with large, prominent eyes, short antennæ and a rather long rostrum or beak. The perfect insect lives upon trees and shrubs, piercing the tissues and sucking out the juices, while the larva, which lives underground, is said to attack the roots of plants. The North American Seventeen-year Cicada (*Cicada septendecim*) is a remarkable insect, on account of its long life-cycle, which lasts for seventeen years; indeed, it has, so far as is at present known, the longest life of any insect. For nearly seventeen years it lives as a larva beneath the soil, often burrowing to a considerable depth; then, after a short, active pupa or nymph stage, it comes to the surface, casts off its pupa skin, and emerges as a perfect winged insect. The male Cicadas are great musicians, and all through the long, hot sunny hours of the tropical day sit concealed amongst the foliage and keep up an incessant song; this is produced by two plates—the *opercula*—on the under surface of the body, which are really very highly developed and complex organs. These vocal organs are not present in the female insects, which cannot produce any sound. Much difference of opinion exists as to whether the song of the Cicada is agreeable or not, some people enjoying it, others considering it most objectionable. Xenarchus, a Greek poet, wrote of these insects and their song: "Happy the cicadas' lives, for they all have voiceless wives." About eighteen species are found in Europe, and one of the smallest, *Cicada hæmatodes*, ranks among the rare insect treasures of the New Forest.

The family **Fulgoridæ** includes the so-called Great Lantern Fly (*Fulgora lanternaria*), which is found in Brazil and other parts of South America. It is a large, handsome insect, with a most extraordinary outgrowth of the front part of the head, that looks rather like an Oriental lantern. It is from these curious processes on the head that the *Fulgoridæ* have gained their popular name of Lantern Flies; but it is extremely doubtful if any are luminous

at night. The Chinese Lantern Fly (*Fulgora candelaria*) presents a very curious appearance, the front of the head being prolonged into a long process that looks like a carnival false-nose.

The **Aphides**, or Plant Lice, are an exceedingly interesting family, not only on account of the damage they cause to trees and various crops, but because of their remarkable method of reproduction. Small and feeble insects individually, they increase so rapidly in numbers that the infested plant is quickly covered by them, and if left untended, sickens and dies. The abundance or scarcity of the Hop Aphis (*Aphis* [*Phorodon*] *humuli*) is an important factor in the quality of the hops; and the cost of fighting this pest makes it very hard for the British farmer to compete against foreign untaxed imported hops. "In France the spread of another species, the dread *Phylloxera vastatrix*, has caused fearful loss throughout the vine-growing districts. Indeed, it is a striking object lesson of the truly appalling destruction insects are capable of causing. In the year 1875 the area under cultivation as vineyards in France amounted to 6,382,000 acres, and in 1885, through the ravages of the Phylloxera alone, it had become reduced to 2,868,000 acres. That is to say, in round numbers, within a period of ten years, four million acres of once healthy and prosperous vineyards had been laid waste by these insects. Fortunately, preventive means have been found to arrest this swift and appalling work of destruction, and the threatened industry saved from total extinction. Nevertheless, the ravages of the Phylloxera have cost France a financial loss far in excess of that of the Franco-German War. This terrible insect foe appears to have first been discovered in North America in 1854, and to have been carried thence on the exported vine-plants to Europe, where it quickly established itself and appeared as a noticeable infestation about 1863. To-day it is to be found in all vine-growing countries. The greatest difficulties have been experienced in attempting the successful destruction of this scourge without injuring or totally destroying the vine-plants, and but for the fact that the Phylloxera has many natural foes, and that these have been wisely cherished and encouraged in the vineyards, it would have been impossible to check the swift and ever-increasing spread of this terrible pest." [1]

[1] "Our Insect Friends and Foes," by F. Martin Duncan.

The method of reproduction among the Aphides is very remarkable. The first of the Aphides to appear in the spring of the year are wingless females, which give birth to living young without the intervention of the male; and these offspring, which are also wingless females, in turn produce living replicas of themselves. This system of non-sexual reproduction is called *parthenogenetic reproduction*, and may be continued throughout eight or nine generations. Sooner or later, however, true male insects, generally winged, make their appearance, and also fertile females, which are generally possessed of wings. The result of sexual intercourse between these is the reproduction of eggs in place of living young. The eggs are generally deposited towards the end of the summer, the young insects emerging either in the autumn or following spring, as wingless females producing living young. The females which produce living young are called *viviparous* females, and those which produce eggs *oviparous*. The fecundity of the viviparous females is enormous, each individual producing hundreds of young. As the viviparous female rarely moves from the position she first takes up, the foliage in her vicinity soon becomes densely crowded with her wingless offspring, which move but slowly, and rarely travel very far from the place of their birth. The result of thousands of these insects crowded closely together, with their sharp, sucking beaks inserted in the foliage, is to exhaust the plant utterly and absorb all its sap, so that the roots and leaves cease to function, and it dies. But with a decrease of the supply of liquid nourishment the viviparous females produce oviparous females, which in most cases are winged, and therefore capable of quitting the over-populated situation in which they are born, and, after intercourse with the males, of starting their offspring on life's race in a more advantageous environment.

The Order **Orthoptera** includes the Earwigs, Cockroaches, Mantis or Praying Insects, Leaf and Stick Insects, Locusts, Grasshoppers, and Crickets. All are characterised by having the front wings of a leathery texture, and much narrower than the hind wings, which are membranous, and often large and fan-shaped. Their metamorphosis is incomplete, the young resembling the adult in general features, directly they leave the egg; while in the wingless forms hardly any difference is perceptible between the larva

The English Cicada, a very rare British insect

Ranatra

Chinese and Brazilian " Lantern Flies "

Adult and young Cockroaches

and adult. Most of the Orthoptera cast their skin at certain periods of their growth. Some of the insects moult three times successively, and still resemble the creature that first came from the egg; a fourth moult takes place, and then the rudiments of wings may be visible; a fifth and final moult leaves the insect with perfectly developed wings. Those Orthoptera in which the organs of flight are not developed only cast their skins three times before reaching the adult stage, while those with rudimentary wings undergo four moults.

Everybody is more or less familiar with the general appearance of the Earwigs, so that it is hardly necessary to give a detailed description of them here. But, although the Earwig is such a common and familiar insect, few people who are not entomologists know that this active little insect, with its slender antennæ and forbidding-looking abdominal pincers, is possessed of a pair of beautiful, gauzy wings which are folded away beneath the short, small, leathery front wings. These transparent, membranous wings are ear-shaped, and reflect the light with a pretty iridescence, so that "Ear-wing" is really the name by which the little insect should be called. Opinions are rather conflicting regarding the habits of the Earwig, and it is very difficult to say whether there is any truth in the popular idea that the insect creeps into the ear of a sleeping person and may cause injury to the brain. There does not appear to be any authenticated record of this having happened, and yet it is a widespread belief, the insect being called *Ohren-wurm* in Germany and *perce-oreille* in France.

Again, the Earwig has been credited with displaying great solicitude for its young, probably on the statement made by De Geer in 1773, which has been quoted by many authors, yet the recent observations of Camerano do not altogether confirm this theory, for although he describes the female as collecting her scattered eggs with care, placing them in a little heap and brooding over them, she evinced no interest in the young when they had emerged

The Cockroaches, the so-called "Blackbeetles," that often swarm in the kitchens and basements of old London houses, on ships, and in seaport towns, are unpleasant and destructive insects. Their long antennæ and spiny legs, their bloated, flat, brownish-black bodies, fetid smell, and sudden swift movements make them very "creepy" and unpleasant insects. Omnivorous in their diet,

they attack everything that comes in their way that can possibly be consumed; nothing comes amiss to them, and the amount of destruction they cause is very considerable. The larvæ, when first born, and immediately after each moult, are of a sickly white colour, and resemble their parents in general appearance, except that the wings are undeveloped.

The **Mantidæ**, or Praying Insects, are a large and interesting family of Orthoptera, showing great variety in the shape and general outline of the body, and characterised by the remarkable development of the front pair of legs into formidable seizing organs for the capture of the living insects upon which the Mantidæ feed. Entirely carnivorous in habit, the Mantis does not actively pursue its prey, but either waits patiently until some unsuspecting victim comes within reach, or slowly and cautiously stalks it. The curious attitude assumed, with the front part of the body (the prothorax) raised, and the front pair of legs held as if in a devotional attitude, has gained for these remarkable insects their popular names of "Praying Insects," or "Soothsayers," and there are many curious legends attached to them. From very ancient times it has been believed that these insects would indicate by the gestures of their fore-limbs the right paths that lost travellers should take; while an old legend tells how St. Francis Xavier, on seeing a Mantis moving slowly along with its fore-legs raised in a devotional manner, exhorted the insect to sing the praises of God, and that it immediately sang a very beautiful canticle. Unfortunately, there is no foundation for these charming ideas; for the Mantis, walking solemnly in a devotional attitude, is really a cruel and voracious impostor in search of prey, and the raised fore-limbs are merely extended in readiness to seize, like a pair of toothed shears, any victim that comes within striking distance. The power of these front limbs is very great, so that the captured prey is held as in a vice, and they are also used for fighting, when a successful stroke, like the sweep of a scythe, will sweep off an adversary's head or legs. These insects are almost entirely inhabitants of the warmer regions of the world, only a few being found in Southern Europe.

The majority of the Leaf and Stick Insects (*Phasmidæ*) are most bizarre in their appearance, looking like withered leaves and twigs, or green growing leaves and mossy sticks. They are easily dis-

LOCUSTS, CICADAS, AND LEAF INSECT

1. 2. Indian Cicadas
3. Cicada from Nias Island
4. 5. African Locusts
6. *Tropidacris latreillei*
7. *Phymateus*
8. Leaf Insect

tinguished from the *Mantidæ* by the construction of the fore-legs, which are ordinary walking limbs, and not adapted for the capture of prey. These insects reside chiefly upon trees and bushes, the leaves of which seem to constitute their sole food; they are nocturnal in their habits, becoming rigid and counterfeiting death when alarmed or handled.

The Crickets, Locusts, and Grasshoppers form a tribe (the **Saltatoria**) of the Orthoptera, the members of which are all characterised by the enormous development of the hind legs for leaping, while the head is large and the mouth parts powerful and strongly developed. The front wings are leathery and narrow, serving as a protective covering to the large and more or less transparent hind wings. At the end of the abdomen in the females of many species we find an ovipositor, sometimes of considerable length and stoutness. The males of most of the species possess the faculty of producing loud chirping sounds, the means by which this is effected varying in different families. The shrill music of the male House Cricket is familiar to most people, and is accomplished by the rubbing of the front wings or *tegmina* over one another, of which Professor Westwood gives the following description :—"In the males of the House and Field Crickets, on the internal margin, about one-third of its length from the base, a thickened point is observed, from whence several strong veins diverge, forming an angle from this point. The strongest of these veins, which runs towards the base of the left wing-cover, is found on the under side to be regularly notched transversely, like a file; when the wing-covers are closed, this oblique base of the wing-cover lies upon the upper surface of the corresponding part of the right wing-cover; and when a tremulous motion is imparted to the wing-covers, this bar rubs against the corresponding bar of the right wing-cover, and thus produces a vibration that is communicated to the other parts of the wing-covers, which, being divided into a number of irregular spaces, have each a distinct vibration, and produce a separate sound," the combination of which produces the familiar shrill, trilling chirp or stridulation.

The Mole Cricket is a large, robust insect, now comparatively rare in England, where it is confined to the southern counties, but abundant in many parts of Europe. In the character of the forelegs this cricket presents a singular analogy with the moles.

These limbs are very stout and articulated in such a manner that they are thrown out from the sides of the prothorax in the most convenient manner for digging, and the tibiæ, which constitute the actual digging parts, are flattened transversely to the axis of the body, triangular in form, and terminated by four finger-like processes. The Mole Cricket leads a more or less subterranean existence, feeding upon worms and underground insects, and probably some vegetable substances. The male flies occasionally in the evening twilight, and produces a dull, jarring note for its song, somewhat like that of the goatsucker or fern owl.

It is unfortunate that the term **Locustidæ** should have been applied to a group of insects that contains none of the Locusts of ordinary parlance, and much confusion has resulted. As a matter of fact, this family contains the Green Grasshoppers and Katydids, insects which, as a rule, are more fragile than the *Acridiidæ*, or true Locusts and Grasshoppers, and they have very long, slender antennæ. The Great Green Grasshopper (*Locusta viridissima*), to be found in the South of England, is a very handsome insect, which produces a shrill, monotonous sound. Bates relates that one of these singing grasshoppers, which is found in Brazil, and called the *Tananá* by the natives of the Amazon valley, has such a pleasing song that it is captured and kept in little cages. The North American Katydids are famous for their song, and, although there are several species, most of them produce a sound somewhat resembling the words "Katy-did." "Katy-did, Katy-did, O-she-did, Katy-did-she-did, Katy-did," is the curious song of these insects, which the males are said to perform in rivalry with one another.

Although comparatively little is known of the habits of the *Locustidæ*, it has been observed that they are not exclusively vegetable feeders, many seeming to prefer a mixed, if not entirely carnivorous diet. Many of the species display in the greatest perfection the resemblance of the front wings or tegmina to leaves, some, indeed, looking exactly like leaves in various stages of freshness and decay.

The **Acridiidæ** includes the common Grasshoppers and true Locusts, which are easily distinguished from the Locustidæ by their short, generally thread-like antenna and the absence of the projecting ovipositor in the females. The song of the male

Leaf-like Locusts

Leaf Insects

Mole Cricket

Great Green Grasshopper

Ant-lion and Ascalaphus

May-fly

Grasshopper, which is such a familiar sound in the long grass bordering the lanes and fields in summer, is produced by the friction of the hinder thighs against the wing-cases, the insect standing upon his four walking legs, and working his hind ones alternately up and down, so that the inside surface, of the thighs pass rapidly over the veins of the wing-cases. The Acridiidæ are provided with organs which are considered auditory in function, as are also the Locustidæ; in the former they are placed on the side of the upper part of the first abdominal segment, and in the latter on the front legs below the knees.

The Migratory Locust (*Pachytylus migratorius*) is probably one of the oldest foes of mankind, and records of its depredations have been handed down from the earliest civilisations of the East. Large swarms of these insects consist of an almost incalculable number of individuals, which look like advancing storm clouds, darkening the sky, and when they alight cover the ground and branches of the trees for many miles. In a few hours every vestige of vegetation has been gnawed down and devoured, so that the trees stand with bare and broken branches, stripped of every vestige of their luxuriant foliage. Then, as if by some recognised signal, the vast devastating army rises and departs, seeking fresh feeding grounds, and leaving behind it pestilence, famine, and despair. The Locusts have a world-wide distribution; in the South of Europe, India, China, Africa, and the Rocky Mountains of North America they abound, and from time to time appear in vast, devastating armies. They do not undergo a complete metamorphosis, the young on emerging from the egg resembling their parents in general appearance, save for the absence of wings. In size they vary from ½ inch to 6 inches in length, and are powerfully built, with strong hind legs, large heads, and formidable mouth organs.

The order **Neuroptera** contains the Termites or White Ants, the May-flies, Caddis-flies, Lacewing-flies, Dragon-flies, Ant-lions, and Ascalaphus, insects which in the adult stage have two pairs of membranous, usually much-veined wings. They form a very diverse order of insects, making it extremely difficult to lay down any definite characters as being common to all. Some, like the so-called White Ants, or Termites, are social, while others are solitary in their habits; some are vegetarian, while others are

carnivorous. A community of Termites consists of a large number of workers, a limited number of big-headed and powerful-jawed soldiers, a fertile queen, and a king, or fully developed male. The apparent similarity of the community to that of the true ants is only superficial, for while the various types of workers in the true ant community are practically all neuters, or imperfectly developed females, in the Termites they are males and females who remain sexually immature throughout their lives. Professor Fritz Müller has also proved that in many instances a Termite community may contain, in addition to the workers and fully developed males and females, who are the true future kings and queens, a certain number of wingless males and females. These are apparently kept in reserve by the community, and, in the event of anything happening to the rightful king and queen, are allowed to mate and become parents. The winged males and females are produced in great numbers at certain seasons of the year, and on completing their growth quit the nest and swarm into the air. Although the male Termites may commence the courtship of the queens during the brief flight, the actual mating does not appear to take place until the amorous couple have taken up their abode in some hospitable nest, and have been formally accepted as king and queen by the community. Then, having lost their wings, or had them pulled off by the workers, the royal couple are established in a special chamber in the centre of the nest, wherein they pass the rest of their lives, tended carefully by the workers. The Termites always work under cover, constructing covered ways to screen themselves from observation and attack, for their soft, plump bodies are much appreciated by insect-eating birds, lizards, and carnivorous beetles and true ants. Their food consists chiefly of wood, especially wood that has begun to decay, and in the tropical forests they attack every fallen branch and trunk, and ascend to the topmost branches of the living trees by forming covered ways of earth. Unfortunately, they do not confine their attentions to the forest, but will burrow upwards through the timbers of the houses, the first warning of their presence being the sudden collapse of some supporting beam, which may bring the rest of the timbers tumbling down, mere hollow shells, excavated by these persistent workers.

The graceful May-flies, so dear to the heart of the enthusiastic

fisherman, have gained their scientific name of *Ephemeræ* from the shortness of the life of the perfect insect, for the majority perish within a few hours of attaining their full development. In the perfect insect the mouth is quite rudimentary in structure, so that the insect cannot take in any food, and the short hours of this climax of its existence are devoted to sexual intercourse for the perpetuation of its species. The larval and the active pupal or nymph stage are passed entirely in the water, and appear to last for two or three years, the skin during this period being cast several times.

The life-history of the Dragon-fly, in which the early stages of active larva and nymph are passed beneath the surface of the pond, is too well known to need detailed description. Fiercely carnivorous at every stage of their lives, the Dragon-flies help to keep down many noxious insects, preying upon aquatic larvæ, as well as upon winged adult insects. In the larva and active pupa or nymph stage, their movements are generally slow; but they can also dart quickly by the sudden expulsion of water from the body.

The Ant-lions (*Myrmeleontidæ*) are in the adult stage slender, elegant creatures, with large wings, not unlike a dragon-fly. The larva, to which the name of "Ant-lion" properly belongs, is an ugly-looking insect, with a stout, short body, not in the least like the graceful perfect insect. The larva can only walk backwards, and in excavating the pit in which it lives it turns round and round, throwing the sand grains out of its funnel-shaped hole with the aid of its large, flat head. The sand, as it is thrown over the sides of the pit, forms an unstable margin, so that any wandering ant or other insect, stepping incautiously upon it, starts some of the sand rolling, and itself struggles to regain a firmer foothold. But the ant-lion at once begins to throw up sand at its victim, which soon comes tumbling down and is at once seized by the sharp mandibles of the ant-lion, which are perforated by tubes, and allow the larva to suck the juices of its prey. When the larva becomes fully grown it forms a silken cocoon to the walls of which a quantity of sand-grains are glued, and within this changes to a pupa, from which in due course the perfect winged insect emerges. The larvæ of Ascalaphides, although closely resembling ant-lions in appearance, do not walk backwards or form pitfalls for the capture of their prey, but hide under fallen leaves and stones.

CHAPTER XIII

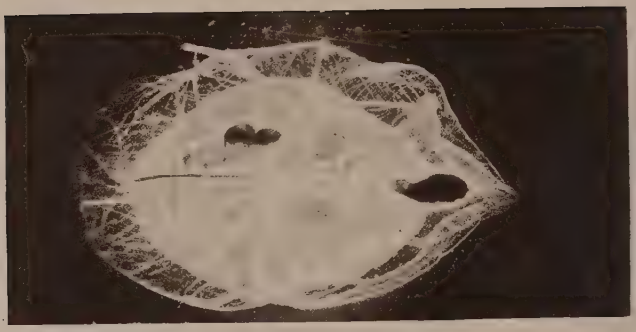
ASCIDIANS AND LANCELETS

The Ascidians (**Tunicata**), or Sea Squirts, are a class of degenerate survivors of ancestral Vertebrates. Their true character was not understood until 1866, when the discovery of their complete life-history showed that they stood at the base of the Vertebrate series. These animals are enveloped in a leathery tunic or mantle—whence the name Tunicata. This tunic is constructed in the form of a sac with two openings, or else in the shape of a tube of varying dimensions. Within this tunic are the viscera, comprising the organs of respiration, circulation, digestion, and a muscular and nervous system. The Ascidians, in their adult stage, have no distinct head and no appendages serving as arms or legs. Though a large proportion are fixed to a base, some are free; some are simple; some show various degrees of combination; others are simple in one generation, combined in another, displaying a regular alternation of generations. All, however, are free during the larval period of their lives, when they present a more or less striking resemblance to the tadpole of a frog, and exhibit unquestionable vertebrate characters, such as the spinal cord, notochord,[1]

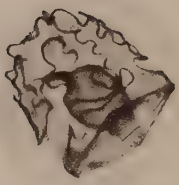
[1] "The axis of the backbone of all Vertebrates is formed by an elastic rod known as the notochord, which lasts throughout life in some of the lowest forms, but in the higher forms appears only in the embryo. The universal occurrence of this structure has been regarded as the most important characteristic of the Vertebrata and their allies, which are accordingly grouped together in the phylum *Chordata*. The members of this phylum are further distinguished from other animals by several important features. Of these one of the most important appears to be the existence of lateral outgrowths of the pharynx, which unite with the skin of the neck and form a series of perforations leading to the exterior. These structures are the gill-slits, and in the fishes their walls give rise to vascular folds or gills. With the assumption of a terrestrial life the higher Vertebrates lost their gills as functional organs, respiration being then performed by entirely different organs, the lungs. But even in these cases the gill-slits appear in the embryo, and remains of one pair can usually be recognised in the adult state of even the highest Vertebrates. Another fundamental characteristic of the Chordata is given by the central nervous system, which lies entirely above the alimentary canal, just dorsal to the notochord. Not only does this position of the nerve-centres distinguish the Chordata from the Invertebrates, but a further point of difference is found in the development. While in Invertebrates the ventral nerve-cord is formed as a thickening of the ectoderm or outermost layer of the embryo, in the Chordata the nervous system is usually formed as a longitudinal

Larva of *Frageria elegans*

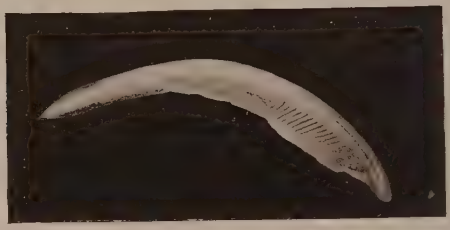
Clavellina lepadiforme



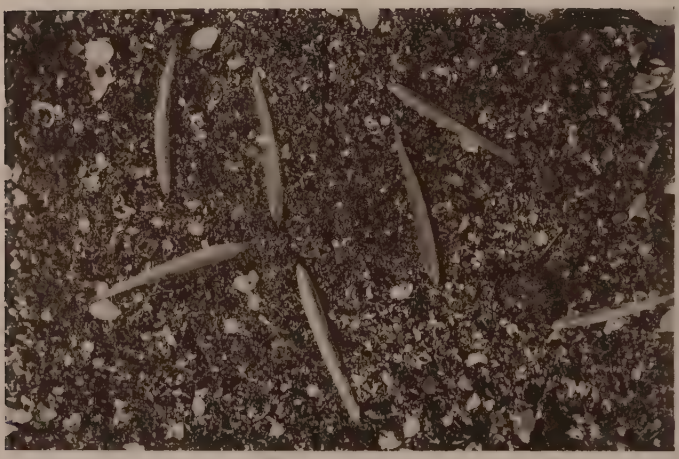
Salpa mucronata



Tonaria larva of
Balanoglossus



Amphioxus lanceolatus



Lancelets (*amphioxus*) resting on the sand under water

brain, cerebral eye, gill-slits, ventral heart, etc. As the adult stage is reached these characteristics disappear, the tail shrivels up, the notochord and spinal cord vanish, the brain is only represented by a small ganglion, and the whole symmetry of the body is altered.

Professor Milne-Edwards divides the Tunicates into three sub-orders, of which the *Ascidia*, the *Salpa*, and the *Pyrosoma* are the types, and he subdivides the Ascidians proper into simple, social, and compound. In the Simple Ascidians the body is sac-shaped, gelatinous or leathery, fixed at one end and free at the other. It has two more or less prominent orifices, one the oral or mouth-opening, the other the atrial or excurrent aperture. The Simple Ascidians, though at times met with as gregarious assemblies of individuals, are not united into groups by a common integument. In *Clavellina* we have an example of a social compound Ascidian, i.e. each individual has its own heart, respiratory system, and organs of nutrition, but is fixed on a stalk or base common to the group, through which the blood circulates in opposite directions, like the ebbing and flowing of the sea. In the true Compound Ascidians the separate envelopes are fused, and lose their individuality, forming a common covering in which all the Ascidians are embedded.

In the family **Pyrosomidæ**[1] the animals are compound and free. The body is cylindrical, hollow, non-contractile, open at one end only, and covered externally by the numerous pointed zooids. The Pyrosomes are from 2 to 14 inches long, and from ½ inch to 3 inches in circumference, made up of innumerable individuals united side by side. They become most beautifully phosphorescent at night, and a vast shoal of these miniature pillars of fire, gleaming out of the dark sea, presents a most wonderful and exquisite sight. The **Salpidæ** are free, alternately solitary, and united in circular or lengthened groups. These Salpa chains vary in length from a few inches to many feet. Chamisso discovered that the solitary Salpæ do not belong to species distinct from those united in chains, however dissimilar, but are either the parents or progeny,

groove running medianly along the back of the embryo. This groove closes to form a tube of nervous matter, the cavity of which always persists throughout life as the central canal of the spinal cord and its anterior prolongation which constitutes the ventricles of the brain."—Prof. Sidney F. Harmer, F.R.S.

[1] Greek, *pyros*, fire; *soma*, a body.

as the case may be, of the aggregate forms; and that the chained Salpæ do not produce chained Salpæ, but solitary individuals, which in turn produce chained Salpæ.[1] The sexes are united, the ovary and testis being closely connected; but in many cases the two sets of reproductive organs are not matured at the same time, so that self-fertilisation is prevented.

Brief mention must be made of the curious and interesting Balanoglossus, considered to be related to the lower Vertebrates. It is a soft-bodied, worm-like animal, which occurs in the sea, burrowing in sand and mud. Its body is divisible into three parts externally: (1) the large club-shaped hollow frontal organ, the proboscis; (2) the prominent fold immediately behind the proboscis, called the collar; and (3) the long and nearly cylindrical trunk. Within the body the most striking anatomical points are the presence of a notochord and gill-slits which are developed as in the Vertebrates, as paired outgrowths of the alimentary canal. The sexes are separate. The progress of development varies in different species, being comparatively direct in some; while in others there is a regular metamorphosis. In the latter case the larval form, termed a *Tonaria*, is so like an Echinoderm larva that Johann Müller, who first described and named it, considered it to be the larva of a starfish. It is provided with a pair of ciliated bands and an independent circlet of strong cilia at the posterior end.

We now come to a small group of marine animals, of which the best-known form is the Lancelet or Amphioxus (*Branchiostoma* [*Amphioxus*] *lanceolatum*), a semi-transparent, slightly iridescent little creature, pointed at both ends and about 2 or 3 inches long. A very noticeable external feature is a series of V-shaped markings along the body, which are due to cross-partitions of connective tissue that divide the longitudinal muscles of the sides of the body into successive blocks or segments. The mouth is just behind the anterior tip of the body, and is surrounded by delicate cirri, which by their movements waft in food particles. The mouth leads into the largest section of the enteric canal, the pharynx, a high, compressed chamber, the walls of which are perforated by more than a hundred pairs of narrow, oblique clefts, the gill-slits or branchial

[1] The above brief outline of the chief characteristics of the Tunicates has been condensed from the writings of Dr. Henry Woodward.

apertures. The notochord extends the entire length of the body, running forward into the snout beyond the spinal cord. There is practically no brain, though two pairs of nerves which pass to the sensitive front and above the mouth are different from the other nerves and may be called cerebral nerves. What is sometimes called the "eye-spot" in front of the end of the spinal cord is only a pigment spot, perceptions of light being produced by what are termed "spinal eyes" at regular intervals right down the spinal cord, and consisting of two cells, one a pigment cell, the other a percipient cell. Water is taken in at the mouth, and expelled through an opening in front of the anus called the "atrial pore."

It will be seen, from the above brief description, that the Ascidians, the Balanoglossus, and the Lancelet have certain anatomical characteristics in common, which are also characteristic features of all vertebrate animals, and therefore, although destitute of any bony skeleton, these animals stand at the base of the great phylum of backboned animals or Vertebrata. The Ascidians, or Tunicates, are grouped by biologists under the head of *Urochordata*, in which the notochord is restricted to the tail; Balanoglossus and its allies are grouped under the *Hemichordata*, in which the notochord occurs in the anterior end of the body only; and Amphioxus comes under the *Cephalochordata*, in which the notochord extends the entire length of the body and of the head. The Vertebrata proper come under the head of the *Craniata*, in which a brain is developed as an enlargement of the central nervous system, while the notochord does not extend farther forward than the middle of the brain, and a vertebral column is present. The Craniata are divided into six groups, or "classes": I. The *Cyclostomata*, Lampreys and Hagfishes; II *Pisces*, true Fishes; III., *Amphibia*, Newts, Frogs and Toads; IV., *Reptilia*, Lizards, Snakes, Turtles and Crocodiles; V., *Aves*, Birds; VI., *Mammalia*, Hairy Quadrupeds, which suckle their young.

CHAPTER XIV

INTRODUCTION TO THE FISHES

EVERY year the study of Fishes, both fresh-water and marine, becomes of increasing importance, not only scientifically, but economically. Those marketable fish which are dwellers in the sea, and which form such an important part of our food supply, are, thanks to modern methods of ice-packing and rapid transit, so easily and cheaply procurable for the table, that the inhabitants of our inland cities and towns probably never give the subject of our fishing industries a thought—except perhaps to grumble when a long spell of winter storms sends up the price of fish for a day or two. And so, here in England, we are living to-day in a sort of fool's paradise, so far as our fisheries are concerned, to say nothing of a good many other important matters, content that there is an abundance of fish for the present, leaving the future to take care of itself. It is a suicidal policy, and one which will cost us dearly in the years to come, if permitted to continue. None are more ready to acknowledge it than the better educated and more thoughtful of the men who are engaged in our great fishing industries. They will tell you, in no measured terms, that the old saying, "There are as good fish in the sea as ever came out of it," can no longer be truthfully applied to certain species. This is not the place to enter into a long discussion on fishery problems, but the subject is so intimately connected with the study of the life and habits of fishes that it cannot be entirely ignored. Thanks to the energy and interest of Sir E. Ray Lankester, the Marine Biological Association of the United Kingdom was founded in 1884, and has ever since its inception applied itself to the advancement of our knowledge of the life and habits of the marketable marine fishes, the organisms upon which they feed at various stages of their life, their migrations, rate of growth, and the effects which modern trawling is having upon their numbers. The results that

have been obtained are of far-reaching importance, and deserve to be far more widely known.

I suppose most people would consider that the chances of ever recovering from the sea a fish that had been marked with a label and liberated would be exceedingly remote; yet Professor Garstang's report on his experiments on marking and liberating plaice shows most conclusively that this is no longer the case in the North Sea. The intensity of commercial trawling in the North Sea to-day is demonstrated by the fact that out of 855 marked plaice liberated outside territorial limits the number recaptured within twelve months yielded a total of 21 per cent.; while experiments on the Dogger Bank in the spring of 1904 resulted in the recapture of more than 40 per cent. of marked plaice exceeding 10 inches in length, in less than twelve months. These figures clearly demonstrate that the total annual catch of the fishermen no longer forms an insignificant proportion of the total stock of plaice living on the Dogger Bank.

These experiments also yielded very interesting evidence of the extensive migrations which the larger-sized plaice are capable of making in a comparatively short time. In one instance a marked plaice, 13 inches long, liberated on December 12th, 1903, on the Leman Ground in the latitude of Lincolnshire, was recovered by a Hastings trawler off Winchelsea, in the English Channel, on March 23rd, 1904, the fish having travelled a minimum distance of 175 miles in a little over three months. Another plaice, marked and liberated on August 12th, 1903, off the Lincolnshire coast near Mablethorpe, was recaptured in April, 1904, in St. Andrew's Bay, having in eight months travelled a distance of 210 sea miles from the point of its liberation.

Another experiment, carried out by Professor Garstang in connection with the Marine Biological Association's work in the North Sea fishery investigations, revealed the remarkably rapid advance in size and weight of young fish when transported to favourable feeding grounds. In this experiment a large number of young plaice were captured in the inshore waters which they frequent in their early stages and were carefully marked, and a given number at once liberated, while the rest were transported to the Dogger Bank, where young, small plaice are not found, and liberated, a previous examination of the bottom having

shown that it was sandy and that certain molluscs upon which the plaice feed were in abundance. An examination of the recaptured marked fish fully demonstrated the very great advantage derived by the fish that had been transplanted to the Dogger Bank, as compared with those liberated on the coastal grounds. The small fish transplanted to the Dogger in April showed an average increase of 62 per cent. in length and 360 per cent. in weight by the following mid-winter ; while the fish left to grow on their usual grounds from April until mid-winter increased only 16 per cent. in length and 59 per cent. in weight. Thus the growth of the transplanted fish, compared with that of the fish left on the coastal grounds, was four times as great in length, and six times as great in weight. The photograph facing page 235 shows the size of the fish at the time of marking, and one recaptured from the Dogger and one from the coastal grounds.

In their general structure fishes are well distinguished from other animals, and their most distinctive structures are their fins, gills and air-bladder. The notochord is converted into firm, granular cartilage, sheathed in bone, and divided into segments by bone deposited in its substance. It extends forward along the base of the skull, and develops two oblong convex surfaces, termed the *occipital condyles*, by which the back of the skull unites with the first vertebra. This mode of union of the skull with the vertebral column is characteristic of amphibians and mammals, and since the other vertebrates have the skull united to the vertebral column by a single occipital condyle, we have here a link in the chain of evolution from fish-like ancestors, for the Amphibia possess, when they commence their existence, many of the structures of fishes. The skeleton of lepidosiren, one of the curious lung-breathing fishes, presents the closest resemblance to that of the lowest class of reptiles. In amphioxus the cranium is represented merely as a forward continuation of the notochord, and gives no conception of the skull as seen in the fishes ; yet a jointed, cartilaginous arch extends downward round the region of the mouth, and is the foreshadowing of the arch, which is more perfectly developed around the mouth in the lampreys and hag-fishes. In simplicity of skull-structure the sharks and rays are the next step in the upward series, but there are many points which place these animals among the highest types of fishes, and

as the modern representatives of the earliest type of fish, as so far demonstrated by fossil remains.

Though the external form of fishes is subject to great variety, being sometimes spherical, or cubical, or expanded, or snake-like, it is generally that of an elongated oval, slightly compressed laterally, a shape which enables the fishes to traverse the water with the greatest celerity and ease. Every part of the body is most wonderfully adapted to its aqueous environment; the fins, tail, and the motion of the whole backbone assist progression, and produce that astonishing ease and rapidity of movement which is so characteristic of fishes. Fishes possess paired front and hind limbs, called the pectoral and pelvic fins, which, although not resembling in any detail the limbs of any land animal, are certainly the forerunners of the arms and legs of terrestrial vertebrates. They are flattened structures, subject to considerable modification of form and size, to which are attached numerous rays serving to stiffen the membrane of the fin. The other fins on the back and belly of the fish are single or unpaired, and are entirely unrepresented in the skeletons of higher land vertebrates.

The modifications of the gills are sufficiently important to give the names *Marsupibranchii*, *Lophobranchii*, and *Elasmobranchii* to certain groups of fishes. In the hag-fish, which is an example of the marsupial type of gill, there are six little branchial sacs on each side; these are produced into short tubes on both sides, and these tubes are prolonged into a longitudinal canal, which extends backward, and carries the stream of water away from the gills on each side, terminating on the ventral surface on each side of a third larger opening, which admits water in the same way into the branchial sacs. In the pipe-fishes (*Lophobranchii*) the gills form a double series of nearly circular tufts, instead of the comb-like form usual in fishes. In the sharks, dog-fishes, and rays (*Elasmobranchii*) the gills are very numerous, and there may be as many as seven gill-pouches, opening separately by slits to the exterior, the first gill-cleft being modified to form a special tube, called the *spiracle*, and only carrying rudimentary gills. In the other fishes this spiracular gill-cleft does not open to the exterior, and is quite rudimentary, while in the land vertebrates we find it converted into the cavity of the middle ear, and its opening into the throat remains as the Eustachian passage. The branchial

chamber is largest in those fishes in which the outlet from it is small. In some eels these outlets approximate close together on the under side of the head; while in the sturgeons and ganoids there is a canal leading from the forepart of each side of the branchial chamber to the top of the head.

The bones which cover the gills are collectively known as the *operculum*. While most fishes are entirely adapted to breathing in water, and must inevitably perish if exposed to the air for even a comparatively short time, there are some which can comfortably withstand a prolonged absence from their natural element. Thus certain fresh-water fishes of the tropics (*Clarias* and *Saccobranchus*) have special chambers leading from their gill-pouches adapted for aerial breathing, and these fishes rise to the surface of the stagnant, muddy pools in which they live, periodically to take in great gulps of air. But of far deeper interest are those fishes which make use of a separate organ, the air-bladder, for purposes of aerial respiration; for this organ is undoubtedly the forerunner of the lung of the land vertebrates. This air-bladder does not occur in the Elasmobranchii, but is a characteristic organ of the Teleostian or Bony-fishes. Though showing considerable variations in its shape and structure, the air-bladder is essentially a hollow, thin-walled sac, often communicating with the throat by means of what is called the "pneumatic duct." In the Teleosts or Bony-fishes the air-bladder, or "swim-bladder," as it is often called, enables the fishes voluntarily to increase or diminish the specific gravity of their body, and has no respiratory function. When the fish, by means of its abdominal muscles, presses out the included gas from its air-bladder its body weight is increased in proportion to the surrounding water, and the fish swims easily at a greater depth. The contrary result is obtained on the relaxing of the tension of the abdominal muscles, and the fish rises lightly towards the surface.

In the remarkable Lung-fishes, or *Dipnoi*, we find a complete transformation of the air-bladder into lungs. In these fishes the position of the air-bladder and its pneumatic duct is exactly the same as that of the lungs and trachea in a true land vertebrate. It is a median or bi-lobed sac with vascular and honeycombed walls, like a lung, and it is supplied by a pair of pulmonary arteries which arise from the sixth branchial arteries, and a pair of veins

which empty directly into the heart. It lies dorsally to the œsophagus, into which it opens ventrally by means of the curved pneumatic duct. Geologically these Lung-fishes are of extreme antiquity, going back in much their present form (the *Ceratodus* which now exists in Australia is identical in shape with a fossil form from the Trias of Europe) to the Devonian, and probably still older Palæozoic formations; and their close relationship to the true ancestors of the land vertebrates is confirmed by resemblances in their anatomy and development.

The organ of hearing is well developed in all fishes, the membranous labyrinth having three semicircular canals, as in the land vertebrates; they communicate with a vestibule, in which are contained the bony plates called *otoliths;* there are usually two of these flattened, somewhat oval organs, and in the cod family one is strikingly larger than the other. In the Elasmobranchii the otoliths are represented by calcareous particles. No fish possesses a cochlea or true tympanic membrane, but sometimes there is a connection between the labyrinth of the ear and the air-bladder, made by a chain of small bones. The otoliths, or ear-stones, of the plaice show alternate white opaque and dark semi-transparent rings, the white rings being formed in spring and early summer, the dark in late summer and autumn. In winter the growth of the otolith, as of the fish, is generally in abeyance. Thus one white and one dark ring is added to the otolith in each year, and gives an accurate means of determining the exact age of the fish. We owe this important discovery to Reibisch, and its confirmation and practical application to Mr. W. Wallace, of the Marine Biological Association. It is a discovery of much importance in relation to practical fishery problems, since it enables a more accurate estimate to be made of the rate of growth of fishes in different regions. By an examination of the otolith it is not only possible to tell directly the age of the individual fish, but examination of the otolith, in conjunction with measurement, gives an accurate insight into the range of size at a given age.

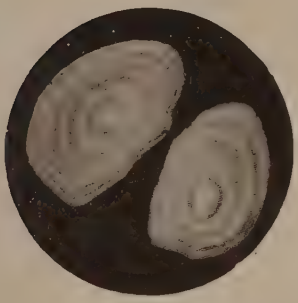
The skin of fishes is rarely naked, in most species being covered with scales which generally present the appearance of thin laminæ or plates, overlapping each other like the tiles on the roof of a house, and embedded in furrows in the skin. Most Bony-fishes possess flexible scales, marked with either concentric or radiating

lines, or both combined. In these scales there is usually a nucleus, which may be irregular. The radiating lines diverge from the circumference of this nucleus. The parts of the margin on the scale between the radiating lines usually project in little convexities, and when the irregularities are limited to one end of the scale, that end is usually implanted in the skin. In many fishes the end of the scale is bordered with tooth-like processes. The parts of a scale are defined in relation to the nucleus or focus from which growth originates; the longitudinal lines which run out from this nucleus sometimes forming furrows, and sometimes perfectly closed tubes. The concentric lines originate in the development of new cells, which become filled with horny matter and ultimately arrange themselves in concentric lines. It must not be supposed that the scales are on the surface of the skin. The skin of a fish, like that of other vertebrates, consists of two layers: an outer, cellular layer, without blood-vessels, which is called the *epidermis*, and a thicker internal layer, fibrous and supplied with blood-vessels, which is called the *derma*. The bases of the scales are situated in this inner tissue, the derma, but their posterior edges may project more or less through the epidermis.

The skin of the dog-fish will offer the student possessing a microscope, and a razor wherewith to cut sections, an interesting introduction to the dermal tissues of fishes. The entire surface is covered with minute placoid scales, or *dermal denticles* (teeth), as they are called, each consisting of a flat base possessing the structure of bone and a pointed projecting spine. The external layer of the spine consists of enamel, below which is a layer of dentine or ivory, the characteristic substance of all teeth, and within this layer is a cavity containing vascular pulp and opening by an aperture in the basal plate; in fact, the whole scale has the same essential structure as a tooth.

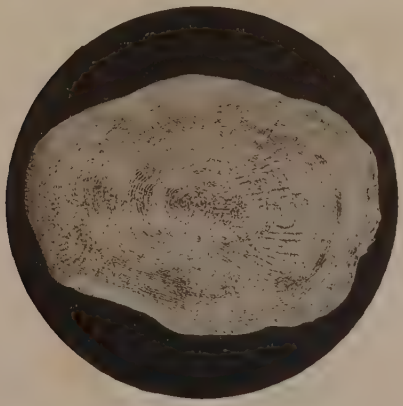
The late Professor Agassiz, impressed with the differences of form in the scales, at one time believed that fishes might be classified by means of them, and he proposed to divide the scales into four types: those which were bony, and formed of a thick, osseous layer, covered with hard, transparent enamel, were termed *Ganoids;* those dermal spines or tubercles seen in the thornback ray and many other cartilaginous fishes, which have a spine

Embryos of Goby



Ear-stones or otoliths of the Plaice

Scale of Sole



Scale of Haddock

Embryos of Dog-fish

Dog-fish and Rays

arising from a more or less circular bony base, were called *Placoid* scales; the scales which have the free margin more or less comb-shaped were termed *Ctenoid*; and those marked with a concentric structure were named *Cycloid*. To the two latter groups the great multitude of living fishes belong, but in the earlier ages of the earth's history Ganoid fishes were the prevailing types.

The concentric rings observable on the surface of the scales of many Teleostean (bony) fishes are an index to the age of the fish. Scale growth is accelerated during the warmer season of the year, but diminished during the colder season in such a way as to cause the formation of annual rings. The formation of these annual rings results from the fact that the lines of growth on the scale surface are comparatively widely separated from one another in that portion of the scale formed during the warmer season of the year, but much less widely separated in that part built up during the colder season. Thus, by following the arrangement of the lines of growth on the scale, it is a simple matter to observe the starting-place of any year's growth by the comparatively wide separation of the growth-lines at that portion of the scale; and in this way the surfaces of scales appear mapped out by annual rings.

The external differences between the sexes are less conspicuous in fishes than in birds and mammals, but are of frequent occurrence and considerable interest. Among the characters peculiar to the males may be distinguished organs usually of an intromittent type concerned in the fertilisation of the ova and introduction of the milt into the body of the female; peculiarities of structure for aiding the union of the sexes; structures which may be displayed during courtship, and weapons used for fighting rival males. In all fishes except the Elasmobranchs and a few Teleosts the fertilisation of the eggs takes place in the water after their extrusion from the female, the male depositing its seminal fluid over the eggs or in the immediate vicinity. The number of eggs produced is often enormous, as we may gather from the following figures given by Dr. T. Wemyss Fulton: In a ling, 61 inches long and weighing 54 lb., the ovaries contained 28,361,000 eggs; a turbot, 17 lb. in weight, had 9,161,000 eggs; a cod, 21½ lb. weight, had 6,652,000 eggs; a flounder, 1 lb. 9½ oz. in weight, had 1,638,000 eggs; while four herrings had respectively 30,000, 26,000, 47,000, and

21,000 eggs. We must remember, however, that out of the large number of eggs produced only a very limited number of young reach maturity. Indeed, the production of a large number of eggs usually implies an enormous destruction of eggs and young, either by the action of enemies, by surrounding conditions becoming unfavourable to their development, or from a scarcity of the natural food supply.

CHAPTER XV

THE ROUND-MOUTHED AND CARTILAGINOUS FISHES

The Cyclostomata, or Round-mouthed fishes, are a primitive class of vertebrates, divided into two orders, the first containing the Hag-fishes or "Borers" (*Myxinoids*), and the second the Lampreys (*Petromyzonts*).

Cyclostomes are distinguished generally by their eel-like form and smooth, scaleless skin, the round, suctorial mouth, which is furnished with horny teeth but no definitely developed jaws, by the absence of paired fins or girdle, the sac-like gill-pouches, cartilaginous skeleton, and unsegmented notochord.

The Hag-fishes are the simplest, and probably the most primitive, of all craniates. They are curious, long, eel-shaped creatures, with a somewhat blunted, conical snout, at the extremity of which is the characteristic round mouth. Above the mouth is a single nostril, the channel by which the water enters on its way to the gills. Four pairs of barbules or short tentacles surround the mouth, and in the roof of the mouth is a single horny tooth. The Hags also possess a powerful muscular "tongue," which works like a piston, and is provided with two pairs of comb-like tooth-plates. This tongue is used as a rasping organ, and has developed to such an extent that the gill-sacs and the heart have been pushed back abnormally far.

These curious creatures have a very wide distribution; they are entirely marine, living in the mud of the sea-bottom at depths ranging from 50 to 350 fathoms, or coiled up at rest among the rocks. They are sedentary in their habits, remaining motionless for long periods, especially during the daytime, but are able to swim rapidly with a graceful, serpentine motion. Down each side of the body is a row of mucus-secreting glands forming a bead-like chain, from which large quantities of slime are ejected.

The Hag-fishes are particularly troublesome to fishermen, and

are especially harmful to the cod-fisheries. Swarms of Hags will attack the fishes caught on the hooks of the long lines, boring their way into their bodies and devouring almost all the flesh with the aid of their powerful rasping tongues. In this way the Hags are said sometimes to destroy whole "catches" of cod, ling, and haddock, nothing remaining of the fishes when the lines are drawn in but mere shells of skin and bones. It is not known whether the Hags attack free-swimming fishes, or confine themselves to attacking those which are hooked or netted, injured or dead; but captured or maimed fishes appear to be their natural prey. The Common Hag-fish (*Myxine glutinosa*) of the North Atlantic is responsible for most of the mischief done to the British cod-fisheries; its depredations are sometimes so extensive that the North Sea fishermen are forced to change their fishing-ground.

The Pacific Hag, common on the seaboard of North America, does just as much damage, and an interesting account of its ways has been given by Miss Julia Worthington in the *American Naturalist*. She writes: "When the night lines are examined, one-third or more of the hooks hold Hag-fish, and the fish on many of the others have been entirely eaten away, nothing but the skin and bones being left. The Hag-fish has bored inside the skin and eaten all the soft parts, and is sometimes caught in the very act of wriggling away at the close of its meal when the fish is taken from the water.

"The Hag does not really suck the captured fishes, but it presses against them and rasps off pieces of skin and muscle. If the fish is a large one, the Hag makes a hole through the body-wall and goes inside. Several often work together, and I have seen three or four inside one fish. In captivity they eat at long intervals and seem able to remain vigorous on a minimum of food. From the nature of their diet it seems likely that opportunities for meals are not frequent in natural conditions, and it is probable that Hags have become constitutionally adapted to do with little food.

"On the ventral wall of the pharynx there is a paired tooth-plate, which some regard as representing the lower jaw. Each half of this plate bears two rows of horny teeth, pointing backwards. When the Hag feeds, the tooth-plate is thrust out of the mouth, and its fore end is drawn down so that it takes a position almost perpendicular to the long axis of the body. The two halves are at the

same time drawn apart, so as to present an almost flat surface. Placing this flat surface against the fish to be eaten, the Hag draws the halves of the tooth-plate together, thus tearing off a portion of the food, and then withdraws it into its mouth. It swallows the food very rapidly, and immediately sticks out the tooth-plate for more." [1]

The eggs of the Hag-fishes are enclosed in a horny, yellow envelope, somewhat resembling a small sausage, about an inch long. At each end are a number of threads ending in anchor-like knobs, and several eggs are usually fastened together in a chain by the entanglement of these hairs. When hatched the young Hag-fishes resemble the adults, and do not pass through a larval state. They attain a length of from 15 inches to nearly 2 feet, but their rate of growth is very slow in comparison with many other vertebrates.

The Hag-fishes are commonly divided into two distinct families: the *Myxinidæ*, which includes a single genus only—*Myxine*—species of which are found on the coasts of Northern Europe, including the British Isles, off the coasts of Japan and Chili and on the Atlantic seaboard of North America; and the *Bdellostomatidæ*, of which species occur on the Pacific seaboard of North and South America, on the coasts of New Zealand and at the Cape of Good Hope. The *Bdellostomatidæ* are distinguished by possessing from six to fourteen pairs of gill-pouches, while the *Myxinidæ* never have more than six pairs.

The second order of the Cyclostomata comprises the **Petromyzonts,** or Lampreys, which, although they have many points in common with the hags, differ from them in several peculiarities. The characteristic round mouth is surrounded by a curious funnel-shaped sucker, fringed with small cirri and dotted all over inside with numerous horny, hook-like teeth. The single nostril does not open into the roof of the mouth as in the hag-fishes, but is placed far back on the top of the head behind the funnel. The eyes of the Lampreys are well developed, while those of the hags are degenerate. The eggs of the Lamprey are small and thin-shelled, and the embryo hatches out as a larva and undergoes a metamorphosis before the perfect adult form is reached. The

[1] "Contributions to our Knowledge of the *Myxinoids*," by Julia Worthington, 1905.

larva is termed the *Ammocœtes* by scientists, but among country people it is popularly known as a "niner"; and it differs so much from the adult form that for a long time it was supposed to be a distinct animal. In place of the characteristic funnel-shaped mouth the larva has a curiously formed upper lip which projects like a hood, while the short lower lip is situated far back beneath it, so that the opening of the mouth is horseshoe-shaped rather than circular. The Lamprey lives as a larva from three to four years, and spends its time buried in the mud of river beds, especially frequenting quiet backwaters or slow-flowing reaches; then during the winter time it undergoes its metamorphosis, appearing in the following spring as a perfect Lamprey. During its larval period the Lamprey is sightless, the eyes being rudimentary and deeply seated. Its food consists of minute organisms which are swept into the mouth by ciliary action.

Lampreys have an almost world-wide distribution. Most species are marine, although several are found in rivers and estuaries, but all Lampreys apparently ascend rivers in the spawning season to deposit their eggs. They are carnivorous creatures, and appear chiefly to feed on living fish, to which they attach themselves by their suctorial mouth-funnel and then rasp off scales and skin and flesh with the horny teeth of the tongue. They often make deep holes in their victims by whom they are carried about, and fishes are sometimes caught with these horrible pests still clinging to their sides. So firmly do the Lampreys cling with their sucking mouths to their victims that it is no easy matter to pull them off, and it is said that a fish can seldom dislodge them when once they have fixed themselves to its body.

The Sea Lamprey (*Petromyzon marinus*), which occurs in the British Isles and also frequents the Atlantic coast of North America and the West Coast of Africa, sometimes reaches 3 feet, or even more, in length; the Fresh-water Lamprey (*P. fluviatilis*), commonly called the "Lampern," measures about 18 inches; and the "Sandpiper," or "Sandpride," the Lesser Fresh-water Lamprey (*P. planeri*), is seldom more than 10 or 11 inches long.

The **Elasmobranchii**, or Cartilaginous fishes, include the Sharks, Dog-fishes, and Rays—an interesting and very primitive race, representing the oldest type of fishes known. The fossil remains of extinct Elasmobranchs tend to prove that they were in all

probability the ancestors of most, if not all, the existing types of fishes. They are distinguished by having a gristly internal skeleton, which in some cases is partly calcified, while the exo-skeleton is formed of "shagreen" or tooth-like scales termed "dermal teeth."

The Elasmobranchs are usually large fishes; none of them is very small, while some of the sharks are huge creatures, the largest of all living fishes. They inhabit almost all seas, the largest species being found in the tropics; they are numerous in temperate waters, while a few species frequent the Arctic region. Many are surface dwellers; others live at the sea-bottom at varying depths to nearly a thousand fathoms. They are typically marine creatures, but will sometimes ascend rivers, and a few species are dwellers in fresh water.

The sub-order *Selachii* includes all modern Sharks and Dog-fishes—Dog-fishes being only a small variety of shark. They are all fierce, active creatures, generally of roving disposition, ranging the surface of the sea, and waging constant warfare on all other denizens of the deep. They are very voracious and, with one or two exceptions, carnivorous, their food ranging from molluscs, crustaceans, or sometimes even plankton, to fishes of all sizes; while many species attack and kill whales, and, as is only too well known, will even devour man should he come within reach of their cruel jaws.

The Shark family are distinguished by their great muscular strength and their strong, toothed jaws. The head is somewhat shovel-shaped, and the mouth, as a rule, is on the under side. The teeth may be blunt and crowded together into great pavements used for crushing food, or sharply pointed and saw-like for rending and tearing. When the latter is the case the sharp teeth, as they are worn down by constant use, are shed and replaced by new ones.

The Great White Shark (*Carcharodon rondeletii*) is one of the largest and most formidable of these dangerous fishes. It frequents the warm tropical and subtropical seas, from the Mediterranean to Australia and New Zealand, and but rarely comes within sight of the British coast. In colour it is an ashen grey above and white below, and it is said occasionally to attain a length of 40 feet, but the more usual size is from 20 to 30 feet. It is a great wanderer, and swims with remarkable swiftness and ease, and will follow the

fastest liners for hours together for the chance of anything in the way of food that may be cast overboard. The White Shark is proverbially ravenous, and will devour anything from a bag of cinders tossed over the side of a vessel to an unfortunate swimmer who ventures in its vicinity. Not only the jaws but the tongue, palate, and throat of this terrible fish are lined with finely serrated teeth, which are broadly triangular in shape and without basal cusps. It swallows enormous quantities of food at a time, its great stomach being capable of expansion to accommodate it.

The Blue Shark (*Carcharias glaucus*) is usually from 12 to 15 feet in length, though out in mid-ocean specimens are sometimes encountered which are quite 25 feet long. On the other hand, the Blue Shark that visits the British coasts in the summer months does not usually exceed 6 or 8 feet. It is a slender, graceful fish, white underneath and a slaty-blue colour above; and, in common with the other members of the *Carchariidæ* family, is distinguished by an absence of spines in the dorsal fins, of which there are two, one in front of the pelvic fins and the second opposite the anal fin. The Blue Shark is a fierce hunter, pursuing and killing quantities of smaller fishes. It often follows the shoals of herring and mackerel, and does a great deal of mischief by cutting and tearing the fishing nets to get at the fish caught within them.

The Topes and the Hounds are members of the same family. They are small sharks, the British Tope (*Galeus canis*) being generally from 4 to 6 feet long, while the Hounds are rather smaller. The Smooth Hound (*Mustelus lævis*), so called from the skin being smoother to the touch than is generally the case with the sharks, is also sometimes called the Spotted Hound, on account of the whitish spots which mark the back.

The Topes, the Hounds, and the Dog-fishes (*Scylliidæ*) are all ground-feeding fishes, and haunt the shallow waters round the coast, preying on small fishes, molluscs, crustacea, and starfishes. Certain species are often very abundant near our shores, and are frequently exceedingly troublesome to the fishermen, as they take the bait from the hooks on the long lines, and cut and break the nets, often doing a great deal of damage. One of the worst offenders in this way is the small Spotted Dog-fish, called by fishermen on some parts of the coast "Robin Huss." Dog-fishes have a variety of curious local names. The Smooth Hound is a "Bastard Rig,"

the common Tope a "Rig," Spiny Dog-fish are "Spur-dogs" in the vernacular of the fisherfolk; and a species of Tope with a long, projecting snout often goes by the name of "Old Shovel-nose" among them.

One of the commonest of the larger sharks seen in British waters is the Fox-shark, or Thresher (*Alopecias vulpes*). It has gained its first popular name from its long, curved tail, or caudal fin, which is supposed to bear some sort of resemblance to a fox's brush; while the curious way it has of beating the water with that appendage is responsible for its second name of "Thresher." This shark grows to about 15 feet, but quite half its length is taken up by its long tail-fin, so that it is not really of a very large size. It feeds on herrings, pilchards, and other small fishes, following the shoals and devouring extraordinary numbers of individuals. When hunting, the Thresher swims round and round the shoal, drawing gradually nearer to the fishes, which huddle together in a mass. While going through these manœuvres the shark keeps up a constant splashing in the water with its long tail in order to frighten and drive its victims to the centre of the circle, where, crowded one upon another, they fall an easy prey.

The Greenland Shark (*Læmargus borealis*) is occasionally captured off the coasts of Great Britain, for, although its natural haunts are in the Arctic regions, this shark, like many of its allies, is a great wanderer, and sometimes ventures as far southwards as the coast of France. It reaches a length of 26 feet, and is a bulky, clumsily built fish, with very small fins. It feeds to a great extent upon the "right" whales, and is said to attack them with great ferocity, biting large pieces out of their bodies with its small but strong, sharp teeth.

The Hammer-head Sharks (*Sphyrnidæ*) are distinguished by the extraordinary shape of the head, which is drawn out on each side into a conspicuous lobe, and has a striking resemblance to a hammer. The shape of the head varies somewhat in different species, of which there are five; in one, called the "Bonnet Shark," the projecting lobes are rounded, forming a crescent-shaped head-piece suggesting an old-fashioned poke bonnet. These sharks are denizens of nearly all the tropical and subtropical seas, but often wander into more temperate waters, and specimens are occasionally captured off our coasts. They are large fishes, frequently

reaching 15 feet in length, and, like most members of their order, extremely voracious creatures.

Another interesting shark is the Basking Shark (*Cetorhinus maximus*). Although one of the largest of its kind, often attaining a length of 40 feet, it is the least offensive of any. It is quiet and peaceful in its ways unless it is attacked, and has a habit of lying motionless on the surface of the water in calm, warm weather, with the dorsal fin and upper portion of its back projecting; it is from this peculiarity it has gained its name of "Basking Shark." Its food consists of small fishes and marine invertebrates, the latter being strained from the water by the curious long gill-rakes which fringe the gill-arches.

The majority of the sharks are viviparous. The true Dog-fishes, however, are oviparous, and the eggs are enclosed, singly, in dark, horny cases, commonly called "purses." The cases are oblong in shape and provided at each corner with a long, curling tendril. As the female Dog-fish extrudes an egg she habitually swims round a tuft of seaweed, so that the tendrils of the "purse" become entangled in the fronds, securely mooring the egg-case to the weed. The eggs do not hatch for several months, and the young Dog-fishes make their escape from the cases through a rupture at one end.

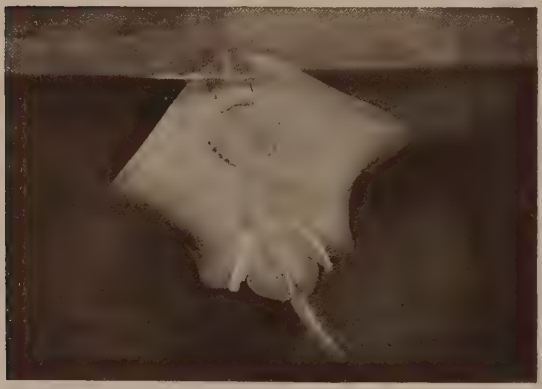
The curious Angel-fish or Monk-fish (*Rhina squatina*) occupies an intermediate position between the sharks and the rays. In its outward appearance, and in its habits, the Angel-fish is distinctly ray-like, but its internal structure has caused its inclusion in the sub-order *Selachii*. It is a most extraordinary-looking creature, with a broad, flattened head and body, the mouth being nearly terminal, instead of on the under surface as in the majority of the sharks. The pectoral fins are very large and wing-like, the two dorsal fins are small and spineless, and placed far back on the tail, and the skin of the fish is studded with tubercles. The distribution of the Angel-fish is very wide; it is frequent on the shores of South Australia and Japan, on the Atlantic and Pacific coasts of North America, on the European coasts, and is not uncommon on the coasts of Scotland. It is often 5 feet long, is viviparous, and commonly produces twenty young at a birth.

In the Saw-fishes (*Pristiophoridæ*) and the True Saw-fishes (*Pristidæ*) we have yet other connecting links between the active,

Angel or Monk-fish

Butterfly Gurnard

Ray swimming



Under surface of Ray

long-bodied sharks, and the rays, with their broad, flat bodies and sluggish ways. The two families approximate one another very nearly, but from the position of the gill-clefts the Saw-fishes have been placed by zoologists in the first sub-order of the Elasmobranchs (*Selachii*), and the True Saw-fishes in the second sub-order (*Batoidei*). In the Saw-fishes the gill clefts are *lateral* (or placed at the side), as in the majority of the sharks; while the True Saw-fishes have *ventral* gill-clefts; that is to say, they are situated on the under side of the body, as is the case with all rays.

Both Saw-fish families are distinguished by the curious long, flattened beak or rostrum—a prolongation of the upper jaw, set along each edge with a series of sharp, pointed teeth, giving this formidable weapon the appearance of a double-edged saw. In shape the Saw-fishes more nearly approach the sharks than the rays, but the body of a True Saw-fish is somewhat depressed. They differ, too, in size, the *Pristiophoridæ* being comparatively small, while the *Pristidæ* are often very large. True Saw-fishes are most plentiful in the tropic seas; they are huge creatures, often armed with "saws" quite 6 feet long, while the entire length of the fish may be 20 feet or more. Like the sharks, the Saw-fishes are carnivorous, and they kill their prey by striking sideways at it with the terrible "saw," afterward ripping and tearing the body with the sharp-toothed edges and swallowing the severed pieces. A blow from such a powerful weapon is naturally a very serious affair, and some Indian species of Saw-fishes that ascend rivers for considerable distances are a constant source of danger to bathers.

Rays or Skates are for the most part sluggish fishes, frequenting the shallow waters round the coast. They are ground-fishes, and seek their food, which consists of crustacea, molluscs, and small species of fishes, at the sea-bottom, over which they move slowly by lazily flapping their huge pectoral fins with a gentle wave-like motion. A typical Ray is very broad and flat, and as it lies half buried in the sand beneath the water it is exceedingly difficult to distinguish it from its surroundings, for, although the under surface is usually white, the back of the fish is almost invariably coloured to harmonise with its environment. This protective coloration is the rule with all fishes of sluggish habits frequenting the bottom of the sea. The pectoral fins are enormously expanded; the tail is long, slender, and whip-like, and usually

bears two small dorsal fins; the caudal fin is small or altogether absent.

True Skates or Rays (*Raiidæ*) are found principally in the temperate seas. Although, on the whole, moderate-sized fishes, some species are very large, measuring 7 or 8 feet across. There are several British species, most of which are of value as food; they are known by various popular names, bearing more or less upon some distinguishing characteristic, such as the "Painted Ray," the "Starry Ray," the "Cuckoo Ray," the "Flapper Skate," the "White Skate," the "Long-nosed Skate," and the "Thornback," the last-named species having gained its name from the spiny tubercles which stud the whole of the back. The tail of the Thornback has a double row of sharp spines, making it a very formidable weapon of offence, and with it the fish often inflicts severe wounds on fishermen who handle it carelessly.

Sexual differences are displayed in most species of Ray, generally taking the form of differences of size or colour. In some—among which are the Thornbacks—the male is distinguished from the female by the formation of the teeth, those of the male being sharp and pointed, while the female's are flattened and blunt.

The eggs of Skates, like those of the dogfishes, are enclosed in tough, horny cases. They have, however, no tendrils, but the points of the four corners are drawn out into stiff, curved horns. The empty egg-cases, from which the young have escaped, are familiar objects on the seashore, and are often mistaken for sea-weed pods.

Many species of Ray carry electric organs at the end of their tails, though these are of a more or less rudimentary nature; but the Electric Rays (*Torpedinidæ*) are provided with a pair of well-developed electric organs situated between the head and the pectoral fins, from which they are able to discharge electric shocks of considerable power. With this useful apparatus the rays stun their foes or the swift pelagic fishes upon which they feed. The Electric Rays differ from the majority of their allies in being rounder in shape, the typical form being rhombic. They haunt the warmer seas, but species are occasionally caught off the British coast.

The Sting Rays (*Trygonidæ*) are characterised by a long, slender, whip-like tail armed with a sharp, barbed spine, which

takes the place of the dorsal fin. This spine is capable of inflicting a severe and often dangerous wound, not only on account of the laceration caused by the barbs, but from the apparently poisonous mucus with which the spine is covered. The Sting Rays are represented by numerous species, chiefly inhabiting the tropical parts of the Pacific and Atlantic Oceans, though some occur in the Indian Ocean, the Red Sea and the Mediterranean. A few *Trygonidæ* live in fresh water, frequenting rivers and estuaries on certain parts of the South American coasts and the southern coast of North America. They often grow to a very large size, and the caudal fin in the bigger species may measure 8 or 9 inches.

The largest representatives of this tribe of fishes are the Eagle Rays (*Myliobatidæ*), often called "Devil-fishes" on account of their terrifying appearance and savage ways. In the tropics some of these creatures grow to an enormous size; one species (*Ceratoptera vampyrus*), frequenting the coasts of the West Indies, is often 20 feet wide. The head of this alarming fish is somewhat rounded, and the cavern-like mouth is furnished with pavement-like rows of huge, flat, grinding teeth, with which it crushes up the shells of the molluscs which form a large part of its food. The pectoral fins stand out one on each side of the body like great wings, and in front of the snout is a pair of horn-like appendages, termed the cephalic fins, said to be used by the "Devil-fish" to push food into its mouth. Altogether, this Ray is one of the most fearsome monsters of the sea, and is greatly dreaded by pearl-divers, who declare that it will envelop a man with its huge, flapping wings and crush him to death in its terrible jaws.

The species of Eagle Ray frequenting European waters are not quite so large and alarming, and do not possess the curious cephalic fins, though many are often of very considerable size. *Myliobatis aquila*, an almost cosmopolitan species, occasionally visits the British coast, and is said sometimes to measure 15 feet from tip to tip of its pectoral fins.

In the Elasmobranchs are also included the Chimæra, sometimes called "King of the Herrings," and the curious Harriotta. The Chimæra is a somewhat shark-like fish, from 2 to 3 feet long, with large pectoral and pelvic fins. The first dorsal fin is covered with a spine, and the head of the male bears a club-like appendage, or clasper. From its habit of pursuing the herring shoals

and devouring the herrings it has gained its popular name of "King of the Herrings"; while from the rather peculiar shape of its head and mouth it is sometimes called the "Rabbit Fish."

The Harriotta are small, remarkable-looking fishes, distinguished by their long, tapering snout, which has something the appearance of a bird's beak, the long, spine-like tail, and large, wing-like pectoral fins. These quaint fishes are mostly dwellers in deep water, and very little is known as to their habits. They are exceedingly rare, and, from the fact that their egg-cases, which are of a horny consistency, are occasionally dredged up from considerable depths, it is concluded that they breed in deep water.

CHAPTER XVI

THE TELEOSTOMI, OR "PERFECT-MOUTHED" FISHES

WHEN we consider that, roughly speaking, three-fourths of the surface of the globe is covered by the sea, it is not surprising that the creatures inhabiting the waters should far outnumber the dwellers on the land. Fishes, in number of individuals, exceed all other classes of vertebrates, and it is fairly safe to say that this is also the case in regard to the number of species. No fewer than 12,000 species of fishes are known, and of these about 11,500 belong to the sub-class **Teleostomi,** or "Perfect-mouthed" fishes. The greater number of this extensive class of fishes is included in the sub-order *Teleostei*, fishes characterised by having a bony skeleton and being clothed with scales. The remaining *Teleostomi* belong to a tribe of fishes forming a series of connecting links between the gristly fishes—sharks and rays—and the bony fishes —herring, cod, salmon—possessing some of the characters of both classes. Between the different classes of fishes there is no hard-and-fast line; the various orders and families appear rather to pass, by a succession of gradual steps, from one kind of fish to another.

To the intermediate tribe belong several extinct forms of fishes which we need not consider here; the most familiar existing representatives are the Sturgeons, the Bony Pikes, and the Bow-fin fishes of America. These "ganoid" fishes, as they are termed, are clothed with scales which, instead of being thin and flexible, as in the majority of living fishes, consist of strong, bony plates, with a highly polished surface, forming a strong defensive armour. The Common Sturgeon occurs in great numbers in the River Volga, and is common also on the east coast of America. It is not infrequently caught in British waters, particularly in the North Sea and at the mouths of large rivers. It is a somewhat bulky fish, sometimes measuring 18 feet in length, with a tail like that of

a dog-fish; it has a long snout, rather broad and flat, and having on its under surface a row of fleshy barbels. Its bony armour is represented by five rows of large, flat plates, which clothe its back and sides. There are about twenty species of sturgeon; a few are fresh-water dwellers, but others live in the sea, migrating, however, to the rivers to spawn. They are extraordinarily prolific fish, a single female being said to be capable of producing about 3,000,000 eggs in a season. The largest member of the family is the Great Russian Sturgeon, which may weigh as much as 2,760 or even 3,200 lb., and measure upwards of 18 feet. The smallest is the Sterlet; this rarely exceeds 3 feet in length, but is nevertheless the most highly prized of all the sturgeons, which are of considerable economic importance.

The Bony Pikes are confined to the fresh waters of North America, and are common in the lakes and rivers from Vermont to the Rio Grande. The genus includes the Long-nosed Gar-Pike, the Short-nosed Gar, and the Great or Alligator Gar, which sometimes reaches a length of 8 or 10 feet. These fishes are distinguished by their mail-clad skins and elongated bodies; their beak-like jaws are furnished with bands of sharp, slender teeth, unequal in size. They are said to be very troublesome in becoming entangled in and breaking the nets set for catching sturgeon, but in the larval state they do a certain amount of good by devouring the larvæ of mosquitos, which abound in the shallow waters. The eggs are always deposited in shallow water, which in the spawning season is often swarming with Bony Pike, both males and females journeying thither in large numbers from the deeper parts of the lakes and rivers ordinarily frequented by them. The Bony Pikes belong to the family *Lepidosteidæ* and must not be confused with the *Belone*, another family of fishes belonging to the *Teleostei* common on our coasts, which are also termed "Gar-Pikes."

The Bow-fin (*Amia calva*) is the sole living representative of the *Amiidæ* family. It haunts the lakes and rivers of central and southern North America, and is extremely interesting on account of its nest-making habits. The fish is about 24 inches long (the male being smaller), is clad in the usual bony armour, though the scales are considerably thinner than in the sturgeon and bony pikes, and bears on the throat two curious comb-like structures.

The Bow-fin is provided with a large, cellular air-bladder which serves as a lung, and the fish is in the habit of rising frequently to the surface of the water (especially when this is at all foul) to take in fresh supplies of air. When acting in this way it is said to emit a bell-like sound, due to the escape of the exhausted air from the air-bladder.

"In the breeding season, which lasts from the beginning of May until June, the fish makes its way from the deeper water, where it has remained sluggish during the winter, to the spawning ground. This is usually at the swampy end of a lake, where there is an abundance of aquatic herbage intersected by channels of clear water. There the fish is said to circle round until the soft weeds and rootlets are bent and crushed aside, so as to leave an area having the appearance of a crude form of nest, in which the eggs are deposited. They may be found in enormous numbers adhering to the leaves and rootlets of the weedy home. After oviposition the male remains on guard until the young are hatched out, when they appear to leave the nest in a body, still under the protection of the watchful parent. At all events, a little later the male has been observed to be accompanied by a swarm of young fry, which he keeps together by circling round them."[1]

To give an exact definition of the **Teleostei** in a few words is practically impossible. To this immense division belong the great majority of living fishes—a vast host which varies to an enormous degree in size, in form, in colour, and in habits. It includes the snake-like Eel, the rotund Globe Fish, the swift and graceful Salmon, and the flat and sluggish Plaice, to mention only a few varieties; while others are of such extraordinary and grotesque shapes that a casual observer might well imagine that they were not fishes at all. Although the majority are clad in sombre hues, some rival the tropical birds in the brilliance of their colour; even in temperate waters many may be seen most beautifully and delicately tinted, but, as usual, the most gorgeous species are dwellers in the warmer parts of the globe, the most vividly coloured fish being found in the tepid waters among the coral reefs.

Roughly, the *Teleostei* may be described as fishes that have a bony skeleton, and are covered with flexible scales more or less

[1] T. W. Bridge, Sc.D., F.R.S.

circular in form. The scales may have a smooth, unbroken edge, when, as has been mentioned they are termed "cycloid" scales, or may be fringed with comb-like teeth and are called "ctenoid" scales. The blennies, however, have no scales at all, and in the eels they are represented by minute vestiges embedded in the skin. The mouth is usually at the end of a snout; the bony jaws are furnished with teeth, and the gill chamber is protected by a broad fold of skin, supported by a complete set of bones, called the gill-cover.

The eggs of Bony fishes differ from those produced by the Gristly fishes. The eggs of a skate or dog-fish are large, few in number, and consist of the yolk surrounded by the white and enclosed within a tough, fibrous case or shell; but the egg of a herring or cod consists only of the yolk (containing the germ), which is enclosed in a thin membrane that has no analogy to the shell of a bird's egg or the tough envelope of a skate's egg. The eggs are usually very minute and produced in enormous quantities. (See p. 209.)

The eggs of Bony fishes are of three kinds—light and separate from each other, in which case they are carried about here and there by the currents of the water; heavy and separate; or heavy and adhesive. In the last two cases they sink to the bottom of the water.

The majority of fishes, after shedding their eggs, take no further interest in them, but leave them to the mercy of the sea and the numerous creatures who feed upon them, the consequence being that only a very small percentage arrive at maturity; hence the reason of the extraordinary fecundity of many fishes. Some species, however, show a certain amount of care and intelligence in providing for the safety of their offspring; while some are really most devoted parents, and take a great deal of trouble in rearing their young.

As in the case of the bow-fin which has already been mentioned, it is, curiously enough, almost always the male fish that undertakes the duties of guardian and nurse; the female, after depositing the eggs, swims away and leaves her mate in sole possession of them; but in a few cases both parents remain on guard and share the labours of tending the eggs and driving away prowling creatures who would devour them. The Butter-

fishes, or Gunnels (*Pholis gunnellus*), common on our seacoasts, behave in this more friendly and equitable manner; both male and female remain with the eggs and take charge of them alternately, coiling themselves round the mass, which thus becomes rolled and pressed into a compact ball. Finally, the Butter-fishes deposit the ball of eggs in a hole in a rock, usually choosing one that has been bored by the little rock-boring mollusc pholas, and it is said that both parents remain near the spot to guard and protect the eggs until the young are hatched.

Of the fishes that build nests for the reception of their eggs, the little Three-spined Stickleback (*Gastrosteus aculeatus*) is one of the most familiar examples.[1] "The nest is a really remarkable structure. The male stickleback first makes a small depression in the sand or shingle at the bottom of the pond, and in this places tiny pieces of weed and fibre to make a soft resting-place for the eggs, and over all he spreads a silken coverlet, formed from a natural secretion that the male stickleback possesses, mingled with particles of fine dust or sand. When the nest is completed, the little stickleback, in all the glory of his courtship colouring, goes forth to seek his lady-love and lead her to the nest. He soon finds out, however, that the old adage that you may lead a horse to the water but cannot make him drink unless he is so disposed applies equally well to his mate, who, although quite willing to observe the nest he has built, shows at first considerable reluctance to enter it; and it requires all the perseverance and powers of persuasion of the excited little male fish to induce her to enter and deposit her spawn. At last, however, the female stickleback goes into the nest, but directly she has deposited her spawn therein she emerges and departs, leaving to her little mate all the anxious and responsible duties of looking after the eggs until the young emerge and can fend for themselves. The male stickleback takes up the burden of his duties quite cheerfully, and tends his precious charge with the greatest devotion, never straying far from the nest until the young are hatched. All day long he mounts guard, attacking and driving away any unwelcome visitors who attempt to approach, and keeping up a constant and vigorous fanning with his fins at the entrance to the nest, thus causing

[1] "The Nature Book." F. Martin Duncan.

a continuous current of fresh, well-oxygenated water to pass through it."

The stickleback is not very difficult to keep, and forms a most interesting addition to the fresh-water aquarium, where we have an opportunity of watching its habits at our leisure.

The larger Fifteen-spined Stickleback (*Spinachia vulgaris*), a marine species, is just as devoted a parent. It makes its nest in sheltered bays, harbours, or sometimes in the rock pools round our coast. The material chosen is usually a tuft of growing sea-weed, or a bunch of hydrozoa, and the fish binds the fronds or branches closely together with a silken thread which he spins from his own body, and is said to be secreted by the kidneys of the male solely during the breeding season. As he spins his thread the stickleback swims round and round the clump of weed and thus forms a species of cocoon, somewhat after the manner of a spider. Over this, when he has induced a female to deposit her spawn inside it, he keeps constant watch and ward until the young fry emerge. The Fifteen-spined Stickleback is apparently the only vertebrate capable of spinning threads in this way.

The nest-building habit is, with one exception (so far as we know), confined to certain fresh-water fishes and marine species frequenting shallow waters. The exception is the work of a fish whose identity has not been established, but is believed to be one of the Flying-fishes. The nest in question is found floating in mid-ocean in the midst of the masses of Sargasso weed in the North Atlantic. It is almost round in shape, about 6 inches in diameter, and is made of fronds of weed bound together by threads, which are not, however, spun by the parent fish, but are bundles of filaments proceeding from the opposite poles of the eggs within the nest.

The little Sand Goby (*Gobius minutus*) is one of the nest-building fishes. The male fish seeks a large, empty shell, usually a pecten shell, lying in an inverted position in shallow water, and industriously scoops away the sand from beneath it, thus excavating a neat little chamber with the shell forming the roof, as it were. In this nest the female Goby deposits her eggs, which are of an adhesive nature, fastening them to the under-surface of the shell roof. The male fish remains on guard to protect the eggs and keep them supplied with a sufficiency of oxygen by the vigorous

action of his pectoral fins, which keeps a constant current of well aerated water flowing through the nest.

Some of the Blennies, and the curious "Lump-suckers" (*Cyclopterus lumpus*), although they do not actually build nests, show great affection for their eggs, guarding them with the greatest vigilance during their period of development. The Rock Blenny fastens its eggs in a single layer within cracks in the rocks or under stones; and the Lump-sucker's spawn is attached in large masses to wooden piles or rocks, or rammed into some convenient hole, in a sheltered situation. The mass sometimes measures as much as 10 or 12 inches in breadth, and 3 or 4 inches in thickness. It seems hardly possible that such an enormous quantity of spawn can be the production of a single female only about 24 inches long, but this point is not certain. Both the Blenny and the Lump-sucker are very pugnacious while mounting guard over their eggs, and will fiercely attack any other fish, or sea creature of any kind, that attempts to interfere with them. The Lump-sucker has even been seen by Dr. Ehrenbaum to bite the finger of a fisherman severely enough to make it bleed when he tried to take away the spawn the fish was guarding.

Amongst other fishes that form nests and care for their young are some of the Wrasses, many of the Catfish, and the common Sun-fishes of the United States. The European Wrasse (*Fabrus*) constructs its nest of a jumble of pieces of coral and broken shells, mixed up with tufts of soft seaweed and hydrozoa, both male and female fishes sharing in the labour. Two South American species of Catfish, *Doras* and *Callichthys*, make rough nests of grasses and leaves, often in holes on the river banks or under logs; or they will sometimes utilise old pails or other tins which have been thrown into the river, as receptacles for their eggs. A more remarkable method of incubation is practised by certain members of the Catfish tribe, and a family of Wrasse-like fishes named *Cichlide*, who carry the eggs about in their mouths until they are hatched, when the young ones are allowed to escape unharmed from their curious nursery. The male Pipe-fishes (*Syngnathidæ*) also carry their eggs about with them, some species having a special brood pouch, after the manner of a kangaroo, situated under the tail, into which the eggs are passed by the female. Other species have a simple groove under the tail, or the abdomen, in which the eggs

are carried; and it is said that, after hatching, the young fry will follow their parent and even return to the brood pouch for shelter should danger threaten.

The **Teostei** are divided into numerous genera, families, and species. The most valuable food fishes belong to the Herring, Cod, Salmon, Mackerel, and Flat-fish families.

The fishes belonging to the great Herring family are never of very large size. They are covered with thin scales without spines, and their fins are spineless too. The head is not clothed with scales, and the snout has no barbels. Near the centre of the back is a small dorsal fin; there is usually a short ventral fin near the tail, and the pelvic fins are below or a little in front of the dorsal. The mouth is large and furnished with small, weak teeth; the air-bladder is well developed and of a more or less simple nature, and the colour of the fishes is bluish or greenish on the back, while the sides are silvery and often iridescent.

The members of this family move about in shoals often containing enormous numbers, swimming in mid-water or near the surface. Their food consists of minute free-swimming creatures which are strained from the water by the gill-rakers, curious sieve-like processes composed of a series of comb-like teeth on the gill-bars.

The Herring family has a very wide distribution, and is of considerable commercial importance, different species ranging throughout the temperate and tropical regions and visiting the coasts in immense shoals at regularly recurring periods, when they are caught in drift, seine, or bag nets. The British species include: the Herring (*Clupea harengus*); the Sprat (*C. sprattus*); the Pilchard or Sardine (*C. pilchardus*); the Shads (*C. alosa* and *C. finta*), and the Anchovy (*Engraulis encrasicholus*).

The "sardine" is the immature state of the Pilchard, caught chiefly on the west coast of France. "Whitebait" is the fry of both Herrings and Sprats.

The Cod family (*Gadidæ*) contains about 120 different species. They are almost all sea-dwellers frequenting the deeper waters, and are carnivorous and extremely voracious in their habits. They are clothed with small, thin, cycloid scales, and their fins are without spiny rays, but their jaws are very powerful and furnished with strong teeth with which they crush the shells of molluscs and crustacea which form part of their food; most mem-

bers of this family, however, will devour almost anything of an animal nature they can capture. They usually feed in the daytime, and hunt their prey on the floor of the sea. These fishes frequent temperate and cold parts of the globe; only a few species inhabit the tropical seas, and these occur in very great depths. Their eyes are well developed, enabling them to see their prey at a considerable distance; and many are distinguished by having one or more curious-looking barbels on the chin or lips.

Several species are common in British waters. They are very valuable food fishes, and are caught by hook and trawl. Amongst the more important are the Cod (*Gadus morrhua*), a large fish sometimes reaching 4 feet in length and weighing about 100 lb.; the Haddock (*G. æglefinus*), the Whiting (*G. merlangus*), the Pollack (*G. pollachius*), the Bib or Pout (*G. luscus*), the Hake (*Merluccius vulgaris*), and the Ling (*Molva vulgaris*).

The curious Bearded Rocklings (*Motella*) that frequent the tidal pools on rocky shores belong to the Cod family; they are strange-looking fishes, distinguished by having three, four, or five prominent barbels on the chin, and are called respectively the "Three-bearded," "Four-bearded," and "Five-bearded" Rocklings. They are ground fishes, and fond of hiding away under stones in shallow water, where, on account of their dull brown hue, they are not easily distinguished. Young Rocklings, however, lead a more active life at the surface of the sea, and are of a bright, silvery colour until they attain a length of about 1½ inches.

The family *Salmonidæ* is noted for the beauty, gracefulness, and gameness of the majority of its species. With the exception of a solitary genus which occurs in New Zealand, the Salmon tribe are inhabitants of the temperate and colder regions of the northern hemisphere. A few species are entirely marine, living in the great depths of the ocean; others live in fresh water; and some live in the sea, but ascend the rivers to spawn.

The true Salmon (*S. salar*) is a really splendid fish, clad in smooth, glittering scales with a silver sheen. It is most wonderfully swift in its movements, and is said to dart through the water at the rate of 86,400 feet in an hour.* In the autumn and winter the British Salmon leave the sea to deposit their spawn in the quiet lakes and rivers, often traversing hundreds of miles, and shooting up rapids, leaping falls and weirs with the greatest

* is rather over 16 m.p.h.

impetuosity and perseverance. They will bound over obstacles 8 or 10 feet high with surprising ease, and will attempt to leap falls of 12 or 14 feet, often with success. If the height is too great to be surmounted, the fish will leap again and again until they become utterly exhausted and are swept away by the strong current. Before the act of spawning the fish lose their brilliant colouring, and become dark and shabby in appearance; the female is much distorted in shape, and the jaws of the male become thickened and prolonged into a sort of hooked beak, which he uses in fighting with his rivals. After spawning the fish are much exhausted, and many of them die. The eggs are deposited on the gravel bottom of streams and rivers, and carefully covered over by the parent fish. They hatch in three or four months' time, and the young fry are termed "samlets." When a year old they are about 8 inches long, and they then set out for the sea. At this stage of their life they are called "smolts," and it is said that in the generality of cases the fish return in the following year to the place of their birth to spawn.

In Scotland spawning takes place in November and December; in North Germany and the south of Sweden, from October to early in November; in Denmark the season is generally in February or the beginning of March.

Amongst other *Salmonidæ* are the bright and active Brook Trout (*S. jario*), beloved of anglers; the Sea or Salmon Trout (*S. trutta*); the Rainbow Trout (*S. irideus*), one of the most brilliant members of the family; the Chars, varieties of which are found in the Swiss lakes, the Alpine lakes of Germany and Austria, and the lakes of Great Britain and Ireland; the Smelts, and the handsome Grayling, distinguished by its upright, many-rayed dorsal fin, and by having a strong scent resembling wild thyme, from which it has gained its specific name *Thymallus vulgaris*, or *vexillifer*.

The remarkable changes of colour and form which many of this family undergo in their migration from fresh to salt water, or in consequence of being artificially removed from their native habitat and transplanted in foreign waters, has rendered their classification a difficult matter, and many trout that were formerly considered to be different species are now looked upon as mere varieties.

While the salmon habitually live in the sea and ascend the

rivers to spawn, the Eels behave in the opposite way. They are fresh-water dwellers that migrate to the sea for the purpose of propagating their species. These migrating Eels pass out from the rivers of Great Britain and of North and West Europe, into the North Sea and Atlantic, shaping their course south-west, right across to a region situated in the Western Atlantic, nearly equidistant between the Leeward Islands of the West Indies and Bermuda. Here, at a depth of 3,000 fathoms or more, spawning takes place, and the continuation of the species secured—the adult Eels perish. From the spawn deposited at these great depths, the baby or larval Eels emerge. Perfectly transparent and flat, in shape somewhat resembling a willow leaf, with tiny head and relatively large eyes, these leaf-like larvæ, or *Leptocephali* as they are called, soon begin to rise towards the upper stratum of the sea, and there, aided by the eastward movement of the surface water, begin their long journey across the Atlantic to the shores and rivers of Great Britain and Europe, whence their parents migrated to the ancestral spawning grounds; a journey that occupies the first three years of their lives.

Their first summer finds them in the Western Atlantic, west of 50° Long. W. By the second summer they have reached central Atlantic waters. In the third summer they approach the coastal banks of Europe, and it is during the autumn and winter of this third year that they undergo the remarkable metamorphosis which converts them from transparent leaf-shaped creatures, some 3 inches in length, into tiny round-bodied, semi-transparent Eels or Elvers. They then move inshore along the coasts and during the spring months of their fourth year ascend the rivers, as Elvers, in vast numbers.

Only two species of eel are found in British waters—the Common Eel (*Anguilla vulgaris*) and the Conger (*Conger vulgaris*). The Common Eel is of a dark olive colour along the back, and white or pale yellow on the under surface. The long, snake-like body is slightly flattened at the sides and at the tail end, and the skin is smooth, with rudimentary scales embedded in it. The female Eel may measure over 3 feet in length when fully grown, the males being always considerably smaller.

The Conger eel is entirely marine, and is easily distinguished from the Common Eel by the larger size of its jaws and eyes. The mouth is very wide, the upper jaw being a little longer than

the lower. The skin is devoid of scales, and is normally dark above and light beneath the body, though some congers have been caught that are of a pale colour all over. Females grow to 6 or 7 feet in length as a rule, though larger ones are occasionally taken; the males are much smaller.

Altogether about 150 species of eel are known, inhabiting fresh water, estuaries, the sea coasts, and, in some cases, the depths of the ocean down to 2,500 fathoms. Some of the deep-sea forms are very remarkable. One called the "Snub-nosed" Eel has a short head with thick lips and huge protruding teeth, distinctly like a bulldog's in character; in other forms frequenting the abysses of the ocean the jaws are prolonged and needle-like.

The Flat-fishes (*Pleuronectidæ*) are ground fishes, abundant along almost all coasts except in extreme northern and southern regions. Those inhabiting the tropics are of little value as food, but in temperate regions the flat-fishes are amongst the most valuable of marketable marine fishes. The chief species found in British waters are Turbot, Halibut, Plaice, Flounder, Brill, Sole, Lemon-Sole, Dab, Witch, and Megrim.

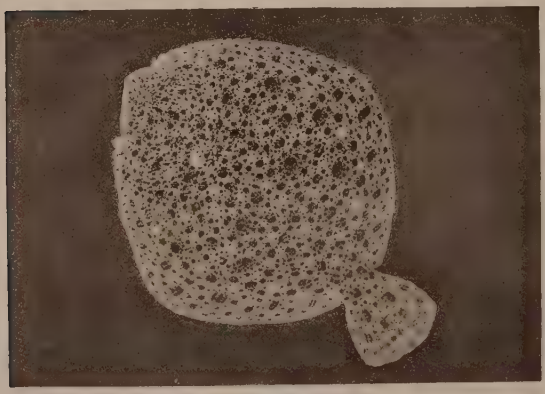
Flat-fishes are chiefly remarkable for being unsymmetrical; that is to say, they habitually lie upon one side, and both eyes are situated on the side of the fish that is uppermost; in addition, the mouth of many species is twisted and lop-sided. Some members of this family are clothed with scales having a spiny margin; in others the scales are rudimentary, or they may be represented by rough tubercles on the skin. The paired fins are usually very small (in some cases altogether absent), the tail fin but little developed, the dorsal and ventral fins very long, without spines, the dorsal fin often extending on to the head—along the edge and not between the eyes.

Some species habitually lie on the right side of the body, others on the left. The side which rests on the ground is white, the uppermost side coloured—light brown, dark brown, or black, and often marked with spots or splashes of yellow, orange, or red. The dull sombre hues of these curious fishes are in a great measure protective, as when in their usual position lying flat upon the ground at the sea-bottom their presence is not easily detected; moreover, they possess in a remarkable degree the power of changing their colour to suit their surroundings. Thus on light, sandy

Embryo of Flounder

Migration of eye in head of Flounder

Marked transplanted Plaice (*See p.* 203)



Turbot

ground the fish will be pale in colour; on muddy ground, almost black; while if the surface of the ground is broken and unevenly coloured, the fish will often be streaked and spotted to match.

The eggs of Flat-fishes are of the separate, buoyant order, and the young when hatched do not resemble their parents in appearance. They are transparent and perfectly symmetrical, with one eye on each side of the body in the ordinary manner, and they swim in a vertical position as round fishes do. At first the tiny creatures lead a free-swimming life, playing about near the surface of the water and feeding on the numerous minute forms of life floating in the sea. Then, while still very small, the fishes take to the bottom and lie down on one side, and a gradual change in form takes place. The roundness of form disappears and the fish becomes flat; the eye on the under side slowly shifts its position and moves round to the upper side of the head; and (in some species) the bridge of the nose becomes bent and the face twisted, giving the mouth the curious lop-sided appearance seen in the Sole and several other Flat-fish. In some cases the migrating eye of the fish travels round right over the top of the head; in others, when the dorsal fin extends to the snout, the eye passes through the fleshy part of the fin, but not (as was at first supposed) through the bones of the head. The larvæ of Plaice and the Common Flounder may be often caught in the spring on various parts of the coast, and if the little fishes are kept in well-aerated water this interesting transformation may be observed in all its stages.

Many quaint and interesting fishes are shore dwellers or visit the coast at certain times of the year, and the young of many deep-sea fishes frequent shallow waters during the early stages of their existence. On rocky shores may be found several of the Blennies, Wrasses, Gobies, and Rocklings. The Smooth Blenny (*Blennius pholis*) is a pugnacious little fish, remarkable for spending part of its time out of the water; it often retires into a crevice in a rock when the tide goes down, and waits there quite comfortably until the water returns to cover it again. The great "Catfish" or Wolf-fish that comes close in shore to spawn in the early part of the year is a member of the *Blenniidæ* family. It is sometimes 5 or 6 feet long, and is exceedingly fierce in disposition; it has been known savagely to attack people wading

in the low tidal pools, its strong jaws and great teeth—the front ones are long and pointed like those of a tiger—making it a very dangerous assailant.

The Gobies have the throat fins joined to form a sucker; but in the Sucker-fishes (*Lepadogaster*) this sucker-fin is more perfectly developed. Several of these little fishes may be found near the shore, clinging, when at rest, to stones and rocks with their curious suckers. The spindle-shaped eggs of the Rock Goby are often to be found fixed to the under-side of stones. They are at first colourless, but as the embryos develop they change to bright green owing to the large green eyes of the little creatures shining through the transparent envelope. If some of the eggs are collected the development of the tiny fishes may be watched, with the aid of a pocket lens, until the membrane of the eggs breaks and the little prisoners wriggle their way out into the water.

A curious fish allied to the gobies is the Walking- or Jumping-fish (*Periophthalmus*), that lives on the mud-flats at the mouths of rivers in tropical Asia, Africa, and North-West Australia. It has a long body, a massive head with protruding jaws, and large prominent eyes set closely together, while the pectoral fins are remarkably developed and used for locomotion on land. Day writes concerning the habits of these strange creatures: "These fishes, from the muscular development at the base of their pectoral fins, are able to use them for progression on mud or for climbing. It is a most curious sight to see *P. schlosseri* along the side of Burmese rivers; at a distance the fishes appear like large tadpoles, stationary, contemplating all passing objects, or else snapping at flies or other insects; suddenly, startled by something, away they go with a hop, skip and a jump, either inland among the trees, or on to the water like a flat stone or piece of slate sent skimming by a schoolboy. They climb on to trees and large pieces of grass, leaves, and sticks, holding on by their pectoral fins exactly as if these were arms. Now and then they plant these firmly as organs of support, the same as one places one's elbows on a table; then they raise their heads and take a deliberate survey of surrounding objects."

The Jumping-fish is by no means the only fish able to move over the land and live for a time out of the water without inconvenience. Some notable examples among the *Telcostei* are

the Climbing Perch (*Anabas scandens*) of Ceylon, that climbs low trees in search of insects by means of the spines upon its gill-covers and ventral fins; the Snake-head (*Ophiocephalus*) of Africa, which crawls about over the mud, sand, or grass; and the Cuchia "Eel" of India, which is quite as much at home out of the water as in it.

The Gurnards, although they do not leave the water, are able to *walk* over the floor of the sea by means of the first three finger-like rays of the pectoral fins, which suggest the legs of a huge insect. These curious processes are used sometimes as legs for walking, and sometimes as fingers to stir up the sand and rake over the loose stones in search of small molluscs and crustaceans on which the fishes feed. The Gurnards are also remarkable for the peculiar grunting noise they make, due to the pressure of the air in their air-bladder.

The "Flying Gurnards" (*Dactylopterus*), an allied family, use their pectoral fins as wings, and take short, flying leaps out of the water somewhat after the manner of the leap of a grasshopper. During their passage through the air the wing-like fins are rapidly vibrated, which is not the case with the Flying-fishes (*Exocœtus*), which belong to a different group of *Teleostei*; the true Flying-fish uses its pectoral fins as parachutes rather than wings.[1] "Their flight, as it is called, carries them 15 or 18 feet high over the water, and the lines which they traverse when they enjoy full liberty of motion are very low curves, and always in the direction of their previous progress in the usual element of fishes. Their silvery wings and blue bodies glittering beneath the rays of a tropical sun afford a most beautiful spectacle when—which is frequently the case—they rise into the air by thousands at once, and in all possible directions."

It is impossible here to notice more than one or two examples of the more extraordinary fishes which frequent the tropical and subtropical seas, some of which are so strange and grotesque in appearance that they resemble fabulous monsters more than anything else. Among these eccentric forms are the Porcupine Fishes (*Diodontidæ*), whose skin is covered with movable spines. They have the power of inflating the body so that it becomes puffed out like a balloon, and erecting all the spines at the same time much as a porcupine does its quills. The Sun-fishes are ever

[1] S. G. Hartwig.

more extraordinary; they appear to consist of a gigantic head, behind which the dorsal and ventral fins stand out like paddles. They frequent the open sea, sometimes descending to great depths, at other times slowly swimming near the surface with the high dorsal fin above the water. The Trunk-fishes, that live in shallow water of the tropical seas, resemble nothing so much as a roughly carved head of a cow. These fishes are encased in a box-like cuirass formed of hexagonal horny plates; two large horns project forward over the large round eyes, and behind this grotesque-looking object the tail fin stands out like a fan.

Better known is the Sea-horse (*Hippocampus*), of the Mediterranean Sea, with its curious head shaped like a knight's head in a set of chessmen, and long prehensile tail. This quaint little fish floats through the water in an upright position, steering its way along with its small pectoral fins. It is fond of coiling its tail round pieces of seaweed or other floating objects, and allowing itself to drift idly with the current. The body of the Sea-horse is encased in bony plates, and its eyes can be moved independently of each other in the same way as the eyes of a chameleon. The male carries its eggs and young in a brood pouch under the tail in the same manner as many of the pipe-fishes, to which family the little sea-horse belongs. The sea-horse has a fairly wide distribution, and species are not infrequent on the south coast of England.

Another curious Mediterranean fish, of a different type, is the John Dory (*Zeus faber*). Its body is very compressed, and the spines on the first dorsal fin are produced into long tendril-like filaments. The skin is almost scaleless, olive brown in colour, with changing lights of gold, blue, and white, and on each side it bears a large black spot surrounded by a lighter ring. Its mouth is telescopic, and can be thrust out to seize prey, which it has a curious manner of securing.[1] "It does not overtake it by superior speed like the mackerel, or lie in wait for it like the angler-fish, but stalks it and approaches it by stealth. It is able to do this in consequence of the extreme thinness of its body and the peculiar movement of its hinder dorsal and ventral fins. The dory places itself end on towards the fish it desires to devour, and in this position it is evident it excites no alarm on the part of its prey. The

[1] Cunningham.

Young Hippocampus

Ribbon Fish

Boar-fish with mouth contracted

Boar-fish with mouth expanded

appearance of the dory seen in this way is a mere line in the water, to which no particular significance can be attached." Slowly and deliberately the dory moves towards its victim, on which its eyes are fixed with intense excitement; then, when it has drawn near enough to the desired object, the tube-like jaw is shot out and the victim seized. The dory is common in the Bristol and English Channels, and is often taken in the trawls on the coasts of Cornwall and Devon.

The Boar-fish, which belongs to the dory family, is also fairly abundant on the south coast in the summer months. It is a small fish, with a greatly compressed body and the characteristic tube-like mouth, and is of a brilliant pink colour. This fish may sometimes be found stranded on the shore as the tide is retreating, and is said actually to flop its way out of the water again if thrown back into the sea.

It is not at all uncommon to find fishes left behind by the tide on sandy, shelving shores; on the Scandinavian coasts the curious Ribbon-fish (*Trachypterus arcticus*) is often cast up by the waves at flood-tide. Ribbon-fishes are remarkable for their long, ribbon-like bodies; the dorsal fin extends from head to tail, the front portion standing erect like a crest. The mouth is tube-like and very protractile, like the mouth of the dory and boar-fish. The Northern Ribbon-fish reaches a length of about 8 feet, and the Oar-fish (*Regalecus glesne*), an allied species, is sometimes over 20 feet long. This great fish, which swims with undulating movements, holding the top of its head and crest above the water, is probably the "sea-serpent" of which we hear from time to time.

The Lung-fishes, or *Dipnoi*, usually called "Mud-fishes," are an old tribe of fishes of which there are now only a few living representatives found in certain rivers in Africa, South America, and Australia. On account of certain peculiarities of structure they are separated by zoologists from all other fishes, and placed in a division or sub-class by themselves. The most distinctive characteristic of these fishes is indicated by their name *Dipnoi*, which means "double-breathers," for, as already stated on page 206, in addition to the ordinary fish-like gills, they possess a highly developed apparatus or "lung" for breathing atmospheric air after the manner of land animals. In some species the lung is single; others have a pair of lungs united in front. The fishes are

clothed with overlapping cycloid scales, sometimes very small and completely embedded in the skin; the fins are long and narrow or leaf-shaped, and the fin rays are not bony, but consist of outgrowths of the skin; the jaws are furnished with strong crushing plates.

The African Mud-fish (*Protopterus annectans*) frequents marshes by the riverside in Central Africa. It is a large and peculiar-looking creature, with a long, eel-like body, having small cycloid scales embedded in the skin, and sometimes attains a length of 6 feet. Its food consists chiefly of frogs, insects, worms, and crustaceans, and it is said sometimes to attack and bite its own kind, particularly if several are enclosed in the same aquarium. During the day the mud-fish is sluggish; at night it becomes more active and moves about over the mud at the bottom of the shallow water on its paired fins, which it uses after the manner of legs, or swims rapidly by powerful strokes of its tail. It is said to be in the habit of rising to the surface at short intervals to take in fresh supplies of air.

During the dry season, when the marshes become dried up, the mud-fish buries itself in the mud and hibernates until the return of the rain, forming a sort of nest or hollow chamber about 18 inches beneath the surface. It remains in a state of torpidity for about six months, from August to December, and when the marshes are once more flooded comes forth in a perfectly healthy condition.

The eggs of the mud-fish are deposited in a rough kind of nest, which is merely a hole on the edge of the swamp in the midst of long grass. The eggs rest on the mud, in the water, and the male fish mounts guard and continuously lashes the water with his tail to keep a well-aerated current passing over them.

CHAPTER XVII

THE AMPHIBIA

"Sweet are the uses of adversity;
Which, like the toad, ugly and venomous,
Wears yet a precious jewel in his head."

Ugly and venomous," I am afraid, is still as much the popular idea of those animals—the frogs, toads, newts, and salamanders —included in the Amphibia as it was in Shakespeare's day. By most people they are still looked upon as "horrid, slimy things," if not as actually dangerous animals, capable of spitting fire and poison. Yet the majority are comparatively harmless and, indeed, most useful animals, and the tongue of the frog and the toad is indeed a precious weapon, capturing with unerring aim countless slugs and caterpillars that would eagerly devour the tender foliage of growing plants. In fact, they are really a most deeply interesting group of animals.

The **Amphibia** have sprung from fish-like ancestors, and in turn have given rise to the Reptilia. Consequently, they occupy a very important intermediate position between the fishes on the one hand, and the higher air-breathing vertebrates (reptiles, birds, and mammals) on the other. They differ from all fishes in the entire absence of fin-rays, and from all fishes except the *Dipnoi* (lung-fish) in the presence of lungs in the adult for breathing air. In the majority of the Amphibia the larval gills become absorbed ere maturity is reached, but in some are retained throughout life, the animal breathing by means of both lungs and gills, after the manner of the *Dipnoi*. The general shape of the Amphibia indicates their more or less aquatic mode of life, the body being either long and cylindrical, or short and compressed, and frequently there is a long, flat tail and a back crest of skin. Sometimes there are no limbs, or only short fore-limbs, or the rudiments of fore and hind limbs furnished with weak digits.

We may divide the existing Amphibia into three orders: (1) the *Apoda* (legless Amphibians); (2) the *Urodela* (persistent tails or newt-like Amphibians); and (3) the *Anura* (tail-less Amphibians).

The members of the **Apoda** have snake-like bodies, no limbs, and a smooth, slimy skin, which forms numerous transverse folds, and may or may not have small scales embedded in it. They live in moist ground and lead a burrowing life. There are some peculiarities in the skulls of these limbless Amphibia which, Huxley pointed out, were foreshadowed in the great extinct Labyrinthodontia of the early age of Amphibia and reptiles. Their life-history has only recently been studied, and in but a few species, so that we have yet probably much to learn about these curious animals. They are found on the slopes of the Himalayas, in Ceylon, Siam, the Malay islands, Borneo, Java, Malacca, West and East Africa, South and Central America.

Of the **Urodela,** the most familiar are the members of the sub-order *Salamandrinæ*, the Salamanders and Newts. The Great Crested Newt (*Triton cristatus*) is the largest of the British Newts, attaining a length of 6 inches, and is fairly common in ponds and ditches, where it preys upon water insects, and in the spring devours large numbers of the tadpoles of the common frog. It will also attack and devour the smaller species of triton; while should two seize upon a worm, a violent tug-of-war takes place until the unfortunate victim is pulled asunder. It is a handsome animal, blackish-brown, with darker spots on the upper surface of the rounded body, and underneath a bright reddish-orange with round black spots. During the breeding season the colouring of the male is very bright, and a handsome crest runs along the back. It is a very aquatic species, rarely leaving the water, and spending the winter in a torpid condition at the bottom of the pond or ditch. The female deposits her eggs upon the leaves of submerged aquatic plants, folding the leaf over so as to protect the egg. The young tadpole at first has external gills that almost look like little plumes, but they gradually become smaller until they are quite obliterated, the gill-clefts in the neck become absorbed and covered with skin, and the little creature begins to respire atmospheric air only.

Nearly related to the Great Crested Newt is the Common Smooth Newt or Eft (*Triton punctatus*), which is less aquatic in its habits,

often leaving the ponds and ditches after the breeding season and wandering about in the rank, wet herbage of water meadows, and sometimes finding its way into cool cellars and out-buildings.

The Spotted Salamander (*Salamandra maculosa*) has a large, thick head and rather clumsy body, with numerous warty growths on the sides, while the tail is cylindrical at its outer end. It is black in colour, with yellow spots. It is a land dweller in the adult state, frequenting cool, damp places, and feeding upon insects, worms, and slugs.

One of the most interesting Mexican Amphibians is the so-called "Axolotl," which is the larval form of *Amblystoma tigrinum*. The colour is a dark grey, almost black, and in the Axolotl stage the animal has three pairs of delicate, much-branched external gills, and a flat, long tail with a broad ventral and dorsal fin, the latter extending along the back almost to the neck. To quote Dr. Hans Gadow: "For many years these creatures were looked upon as a species of *Perennibranchiata* under the generic name of *Siredon*, although Cuvier suspected that they were but the larvæ of an otherwise unknown terrestrial *Urodela*. The mystery was not cleared up until the year 1865, when some Axolotls which had been kept for a year in the Jardin des Plantes at Paris suddenly began to pair, and laid eggs which within six months developed into full-sized Axolotls. This certainly looked as if these creatures were not larvæ, but a true *Perennibranchiate* species. But to the general surprise several of these young Axolotls gradually lost their gills, the clefts closed up, the fins of the back and tail disappeared, the head became broader, the creatures left the water permanently, and, in fact, turned into the already well-known terrestrial *Amblystoma tigrinum*. The other brothers and sisters of the same brood remained aquatic Axolotls, which thereby revealed themselves after all as the larval and not as the perfect stage of this remarkable species." The natural causes which lead to this species of *Amblystoma* frequently remaining throughout life in the larval state, but developing generative organs, are not yet clearly understood.

The *Sirenidæ*, or Sirens, are Amphibians with long bodies and short limbs, the hind limbs being deficient in some. The Siren, which frequents the stagnant waters and marshy ground of South Carolina, is an olive or deep greenish-black coloured, eel-shaped

creature. Its front limbs are small and ill-developed, and bear four digits each ; and it has no hind legs. On each side of its neck it has three very visible gills, increasing in size from the first to the third, and bearing branchial outgrowths. Its eyes are small and covered with skin, and the lungs are bag-like and long. This Siren frequents the rice-fields, where it probably does good service, as its food appears to consist of aquatic insects and worms. It burrows in the soft, moist mud, sometimes leaving this favourite situation to swim rapidly in the water of the ditches, or to wander over the dryer land.

The eel-shaped Proteus is found in Carniola and Dalmatia, in the great underground damp caves and subterranean lakes and streams of those interesting districts. When swimming, the Proteus has somewhat the appearance of a lizard, with small fore and hind limbs, and a tuft of branchiæ on either side of the neck. It is over a foot in length, and about as thick as a man's finger; it possesses rudimentary lungs.

The order **Anura** contains the tail-less Amphibia, the Frogs and Toads. Nearly all pass through a visible metamorphosis, the young emerging from the egg as tadpoles with external gills, and leading an aquatic life, existing very much after the fashion of fishes, moving and breathing like them, until the fore and hind limbs and lungs are developed. They then come to land and become air-breathers, crawling and leaping about in search of the insects, slugs, and worms upon which they live. It is the largest order of existing Amphibia, and contains about 900 species.

The Common Frog (*Rana temporaria*) is greenish-brown in colour, and is to be found in almost all parts of Great Britain, so that it is probably the most familiar of our native Amphibia. Its habits are distinctly terrestrial, frequenting damp meadows and ditches, but, according to Bell, sinking to the bottom of the ponds on the approach of winter, spending the winter months in a torpid condition in the mud, safe from the reach of frost. With the return of spring they come forth, and the egg-laying soon begins, every pond and ditch containing masses of the familiar gelatinous spawn.

The Edible Frog (*Rana esculenta*), common on the Continent, is found in Cambridgeshire and Norfolk, and is much more aquatic in its habits than the Common Frog, from which it can be distin-

Newts

Common Toad

Edible Frog

guished by its larger size, the external vocal sacs, the toes webbed to their extremities, and a prominent glandular patch of skin behind the eye. This frog croaks much more than the common species, numbers collecting together and croaking in concert throughout the night. The American Bull Frog is also well known for its vocal powers, and in the breeding season hundreds collect together and keep up a tremendous croaking that can be heard for a long distance.

The curious so-called "Flying" Frogs are natives of the islands of south-eastern Asia and Madagascar, where they live amidst the luxuriant tropical foliage. Wallace in his "Malay Archipelago" states that one of these little frogs was brought to him by a Chinese workman, who assured him that he had seen it come down in a slanting direction from a high tree, as if it flew. Dr. Hans Gadow, who has measured the specimens brought home by Wallace, and now in the national collection, gives the greatest length of body as $2\frac{1}{2}$ inches, and the area of surface covered by the expanded hands and feet as about 3 square inches (18·8 square centimetres). It is stated that the great enlargement of the fully-webbed hands and feet helps to sustain the little frog in its passage through the air as it leaps from branch to branch.

The Tree Frogs gain their popular name from their habit of life, for they are seldom seen upon the ground, leading for the most part a truly arboreal life, for which they are wonderfully adapted both by coloration and modification of the toes for clasping the branches and foliage. The little European Tree Frog (*Hyla arborea*) is bright green on the upper surface of its body, and paler beneath. It is a pretty little creature, and as it rests quietly among the leaves is very difficult to detect, its coloration blending wonderfully with its surroundings. The Pouched Tree Frog of Central America is of interest for the curious brood-pouch which is present on the back of the female. In the breeding season the attendant male gathers up the eggs as they are laid by the female, and with the help of his hind legs places them in the pouch on her back, where the tadpoles undergo the whole of their metamorphosis. Probably the most extraordinary method of rearing the young is that of Darwin's Frog (*Rhinoderma Darwini*), in which, as the female extrudes her eggs, the male passes them into his enlarged vocal sac, wherein the young undergo their metamorphosis,

and then make their entry into the world by way of their father's mouth.

Toads make very interesting and useful pets in a garden, for the number of slugs, caterpillars, and worms they will devour is astonishing. If kept in a cage, care should be taken to provide a large shallow pan of water for them, as they delight to bathe and literally soak themselves in water. I have for years kept numbers of British and foreign toads, and provided they are supplied with the shallow pan of water, which must only be deep enough partially to cover them, so that the head and back are exposed above the surface when the toad sits up, they will be perfectly healthy, happy, and contented. They become very friendly with those who care for them and feed them, taking meal-worms or caterpillars from the open hand quite fearlessly. In the spring the Common Toad (*Bufo vulgaris*) betakes itself to the neighbouring pond, where courtship takes place, and the eggs are laid in long gelatinous strings, not in a mass like the spawn of the frog. The tadpole is smaller and darker than that of the frog, and its metamorphosis appears to cover a rather longer period. The toad hibernates during the winter months, getting into mud, or down holes, and cracks in the earth; and it is the finding of these hibernating toads in unusual places that has given rise to the imaginary stories of their living for years or centuries walled up in the solid rock or the heart of a tree. The late Dr. Buckland proved most conclusively by actual experiments that no toad can live for two years without food and water.

The Natterjack Toad (*Bufo calamita*) is of a light, yellowish-brown colour, clouded with dull olive, and has a bright yellow line running down the back. It is a lively animal, moving fairly rapidly along with the body well raised from the ground.

The Agua or Giant Toad (*B. marinus*) of Central and South America frequently reaches a length of 6 inches and a width of 4 inches as it squats on the ground. In the rainy season large numbers of these huge toads make their appearance, hopping about with surprising agility. The Pantherine Toad is a native of north-western Africa, Algiers, and Morocco, and is a very handsome animal, measuring 3 to 4 inches in length. On its upper surface it has a dark-edged pattern of brown or olive patches upon a light buff-coloured ground, while the under sur-

face is a uniform white. It is a very gentle creature, and soon becomes quite tame and fearless in captivity. In the Midwife Toad (*Alytes obstetricans*) the male pushes his hind limbs through the convoluted mass of extruded eggs, and then withdraws into his hole, coming forth at night in search of food and to moisten the eggs. After a full three weeks, during the whole of which time the male has carried the eggs bound round his thighs, the tadpoles are nearly ready to escape, and he then seeks and enters the nearest water, the gelatinous cover of the eggs becomes moistened, and the young are enabled to burst through and make their escape.

The most ancient Amphibia appear to have first lived during the Carboniferous Age. Some were lizard-like, others were more snake-like, and some were more like salamanders in shape. Their remains have been found in the Carboniferous, Permian, Triassic, and Tertiary deposits.

CHAPTER XVIII

THE REPTILES

The class **Reptilia** includes the Snakes and Lizards, the curious New Zealand Tuatera, the Turtles, Tortoises, Alligators, and Crocodiles. They are the only cold-blooded vertebrates, and the ventricles of the heart are not completely separated. They have a single occipital condyle to the back of the head, have a scaly or bony-plated skin, breathe by lungs, and lay eggs or produce living young. The Reptilia take up a very central position in the evolution of the main classes of the vertebrates, for on the one hand they have undoubtedly evolved from some branch of amphibian ancestors, and on the other hand have given rise to the mammals and birds. The existing Reptiles may be divided into four orders, namely, the *Chelonians*, or Tortoises and Turtles; the *Crocodilia*, or Crocodiles and Alligators; the *Saurians*, or Lizards; and the *Ophidia*, or Snakes.

Tortoises and Turtles are familiar to most people in appearance. They are cold-blooded, four-footed reptiles, protected by a buckler or "shell," and possessing no teeth in their jaws; characteristics which distinguish them from all other animals. They frequent land, fresh water, and the sea, and have a very wide geographical distribution. While all lay eggs, and, with the exception of the marine forms, pass some part of the year in hibernation, some are carnivorous, some prefer a mixed diet, and others are strictly vegetarian. The buckler is a deeply seated, bony framework, that part which covers the back of the animal being called the *carapace*, while that which is below the body is known as the *plastron*. The carapace is a modification of the bones of the vertebral column and ribs, and also consists of bony plates which, growing in the skin, unite all together. The under part of the buckler, the plastron, is formed exclusively of skin or dermal bones, and usually consists of nine pieces or plates, more or less

developed. The "tortoiseshell," which is the ornamental horny covering of the carapace and plastron, and out of which hair-combs and other articles are manufactured, is to all intents and purposes an outside or "scarf-skin" structure belonging to the epidermis. It is in the form of thin plates, which are united together at their edges, and which correspond to a certain extent only with the underlying bones of the buckler.

The eggs of the Land and Fresh-water Tortoises are of a calcareous nature outside, but those of the Turtle are leathery or parchment-like to the touch. The egg-producing organ is very similar to that of birds, and the internal structure of the egg and the development of the young in its early stage differ in no very essential circumstances from those of the bird. Both carapace and plastron are formed before the young break out from the egg.

Truly wonderful are the Giant Land Tortoises inhabiting the Galapagos Islands, and it seems a sad pity that they are probably doomed to total extinction in a few more years. Darwin in his "Journal of the Voyage of the *Beagle*" gives a most deeply interesting account of these gigantic reptiles. He states that the old males are the largest, the females rarely growing to so great a size, and that "during the breeding season, when the male and female are together, the male utters a hoarse roar or bellowing, which, it is said, can be heard at the distance of more than a hundred yards. The female never uses her voice, and the male only at these times." Of the water-drinking habits of this tortoise, he writes: "The tortoise is very fond of water, drinking large quantities, and wallowing in the mud. The larger islands alone possess springs, and these are always situated towards the central parts, and at a considerable height. The tortoises, therefore, which frequent the lower districts, when thirsty are obliged to travel from a long distance. Hence broad and well-beaten paths branch off in every direction from the wells down to the seacoast; and the Spaniards, by following them up, first discovered the watering-places. When I landed at Chatham Island I could not imagine what animal travelled so methodically along well-chosen tracks. Near the springs it was a curious spectacle to behold many of these huge creatures, one set eagerly travelling onwards with outstretched necks, and another set returning, after having

drunk their fill. When the tortoise arrives at the spring, quite regardless of any spectator he buries his head in the water above his eyes, and greedily swallows great mouthfuls, at the rate of about ten in a minute. The inhabitants say each animal stays three or four days in the neighbourhood of the water, and then returns to the lower country; but they differed respecting the frequency of these visits. The animal probably regulates them according to the nature of the food on which it has lived. It is, however, certain that tortoises can subsist even on those islands where there is no other water than what falls during a few rainy days in the year."

None of these huge tortoises are known on the mainland of America, which is the nearest continent, and it is a remarkable and most suggestive discovery that their nearest allies in size and structure formerly lived thousands of miles away across the Pacific Ocean, in the Mascarene Islands, the island of Rodriguez, and in the island of Aldabra, north-west of Madagascar.

The tortoise which is imported into England and often sold on hawkers' barrows in the streets is the Grecian Tortoise (*Testudo Græca*), and comes to us from most of the countries bordering on the central and eastern ports of the Mediterranean Sea, from Greece, Turkey, Asia Minor, and Dalmatia. The unfortunate reptiles are shipped over in large numbers, frequently not under too humane conditions, and on arrival are hawked round the streets of our suburban districts as being useful for destroying slugs and insects in the garden or cockroaches in the house. The kind-hearted purchaser of a specimen, who gives his or her new pet the run of the garden, soon realises that the tortoise is entirely vegetarian in its habits, and delights to browse upon all the more succulent plants. They are particularly fond of dandelion, plantain, and daisy leaves, and will methodically range the lawn in search of these troublesome weeds, so that they may help to keep them in check; but they are equally fond of violas, sweet peas, and other treasures of the border. They live for many years in captivity if looked after and kindly treated, and become very friendly. One which I kept for many years had a great regard for the family cat, and every spring, on awakening from its long winter sleep, which was passed in a box of hay kept in an outhouse out of reach of damp and frost, would always walk up to the cat, and

Common Tortoise

Giant Galapagos Tortoises

A Young Crocodile

The Alligator's Smile

standing in front of him, bob its head in and out in a most comical salutation. During the summer months, when I did a great deal of my literary work in the garden, the old tortoise would always come up to greet me, and would stay by my chair as if pleased to be near me.

The River and Marsh Tortoises, with but one or two exceptions, lead a land and water life. Their limbs are more slender than in the Land Tortoises, and the carapace, as a rule, is flatter, but it is bony and has a well-developed horny covering. To this group belongs the Common Terrapin, or American Box Tortoise (*Cistudo Carolina*), which has a very wide distribution in the United States and in North America, from Maine to Florida, westward in Texas, Iowa and Missouri, and in Mexico. It is carnivorous in its habits, feeding upon insects, worms, and also some plants and fruits. The Alligator Terrapin, or Snapping Turtle (*Chelydra serpentina*), has a comparatively small buckler, but is provided with a plated head armed with a hooked beak. It is an active swimmer and very destructive among fish, for it is a most voracious reptile, greedily devouring any animal substance that may come in its way.

There are three genera of the Marine Chelonians, or Turtles, the first (*Chelonia*) including the Edible Turtles, of which the Green Turtle (*Chelonia midas*) is the type. They are free swimmers in the great oceans within the tropics, liking deep water, but coming on shore to deposit their eggs in the sand. Although very clumsy and cumbersome on land, they swim easily and gracefully, even the largest individuals, which may be 7 feet in length and weigh 800 or 900 lb., moving with remarkable agility through the water. While the Green Turtle is always used at City banquets, the tortoiseshell of commerce is the product of the Hawk's-bill Turtle, and is derived from thirteen overlapping bony shields on the carapace. The Logger-headed Turtles are probably of more than one kind; their body is broad in front, and the marginal rim is thin and broad behind. Geologically, the tortoises and turtles are a very ancient order.

The Nile Crocodile may be taken as the type of the order to which it belongs. The long body is depressed and protected on the back with solid keeled scales or "scutes." The limbs are short and exceedingly powerful, and the toes are united, more or less, by a web; while the laterally compressed, crested tail is

longer than the body. The head of the crocodile presents a striking appearance on account of its length of jaw and the number of sharp-pointed teeth exposed to view; it snaps and tears at its prey, and thus wears or drags out its teeth, which are constantly replaced by larger ones. When a crocodile drags a struggling animal into the water in its jaws, it shuts its nostrils, sinks down, and closes the back of its throat by muscular action which brings the upper and lower membrane folds together. No water can then pass into the throat. After a while the crocodile just raises the tip of its snout above water, opens the valves of its nostrils and takes in air, which passes along the passage above the palate, behind the folds of skin into the throat, and thence into the lungs. The eggs of the crocodile are small, about the size of a goose's egg, and the young come forth looking very like the parent in shape, with large eyes, a great gape, and a fine set of sharp teeth.

The chief distinctions between the crocodile and the alligator are the short, broad head of the latter reptile, its very unequal teeth—the fourth lower tooth fitting into a socket instead of a notch in the upper jaw—rounded hind legs, and toes not webbed beyond the middle of their entire length. The scales of the body and neck are also arranged differently, forming in some alligators a continuous armour.

S. F. Clarke, who has made a careful study of the American Alligator (*Alligator mississippiensis*), writes concerning their habits that " usually one finds them in the waters of the smaller streams and ponds, lying with only the tip of the nose and the eyes exposed, or lying on an exposed place on the bank where the grass and other plants are beaten down, and the black, rich mud of the river bank is smoothed by the repeated movements of the alligators in climbing up and down. There they bask in the sunlight until disturbed by the hunter or the desire for food. They frequently dig a cave for themselves in the bottom of the pond or stream, or in the bank beneath the water. During the breeding season, from the end of May to the beginning of July, the males are very active, wandering about to various ponds and rivers in search of the females. Fierce battles are said to take place during this time between the excited males ; and the mutilated specimens that one sees are weighty evidence for the truth of this assertion. It

is in the breeding season also that their bellowing is mostly heard, and more in the night than during the day. The largest specimen I saw measured 12 feet in length; and none of the many hunters and other natives of Florida I have met have seen any longer than 13 feet."

Another extract from the same author throws very interesting light upon the results that are being produced by the war of extermination carried on against the alligators, results that can hardly be classed as beneficial: "The alligators are rapidly diminishing in numbers under the high prices offered to the hunters for their hides. Both whites and Indians make increasing war upon them. The pioneers and settlers always destroy the nests and eggs because the alligators eat their pigs; and the cleaned eggs and young alligators are sold by hundreds in the curio shops farther north. As their numbers diminish in Florida it is noticed that the moccasin snakes increase. In Louisiana also the alligators are disappearing; and there the musk-rats are at the same time increasing, and are doing much damage by burrowing in the levees along the Mississippi. While the alligator can make a very stout fight, I have never seen one offer fight if there was any chance of retreat. They never offered to molest us, even when we waded through the ponds where they were."

The Lizards are very numerous, and present much diversity of shape and habits. Some resemble the crocodiles, but have neither their bony-plate armour nor their socket-implanted teeth. Others resemble the Common Lizard, and the rest are more or less limbless. All, however, have a more or less perfect shoulder-girdle and sternum, and four limbs are generally, though not invariably, present. The European Green Lizard makes an interesting pet, and is very beautiful with its fine colour, slender body, and long tail. It soon becomes tame, coming on to the hand in the most confiding manner for such dainties as a meal-worm or nice fat bluebottle-fly. Care is necessary in handling the lizard, and on no account should the tail be suddenly grasped, or it is almost certain to part company from its owner, and will continue to show movement for some time after it has become detached. The loss of a portion of the tail does not seem seriously to disturb the lizard, and in due course is reproduced.

The Monitors are all large lizards frequenting warm countries

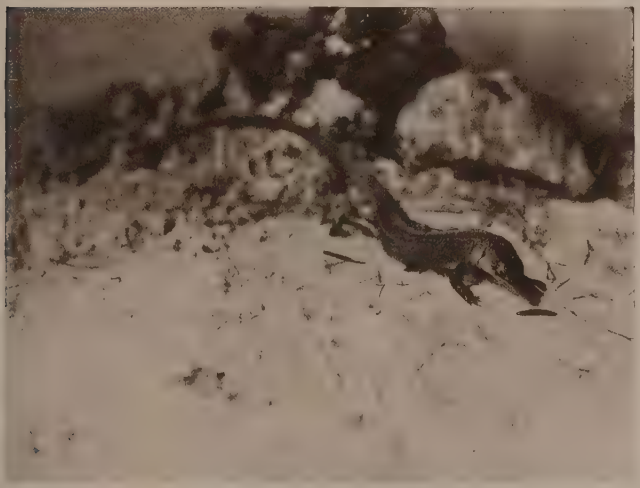
and the tropics; the Nile Monitor attaining 6 feet in length. They vary in habit and food, some frequenting the borders of rivers and streams, and plunging into the water if alarmed; others living in dry and sandy situations.

The Iguanas are lizards which live an arboreal life in tropical America and the West Indies. They climb with ease and move with great agility amongst the foliage, and do not hesitate to take to water when alarmed. The most curious, perhaps, of the American iguanas is the Basilisk, which looks more like some heraldic beast from a coat of arms than a real and active tree lizard. Its broad and rather sharp-pointed scaly head has a tall, cap-like crest sticking up and back from the hinder part. A tall, thin, fin-like, movable crest with spines on it passes along the back, being highest over the loins, and there is a corresponding one on the top of the long tail. The body is scaly and marked in zigzags. Equally extraordinary in appearance are the nearly related Flying Lizards and the Frilled Lizards, inhabitants of the East Indies and Australia.

The Geckos are curiously shaped, thick-bodied lizards, with clawed, flattened-out toes, given to scampering up and down walls and along the ceiling and all sorts of slippery places with the greatest ease in the pursuit of the insects upon which they feed. They are an interesting family on account of their world-wide distribution, and are of great antiquity. The males, as a rule, are more brightly coloured than the females, but in both sexes the coloration resembles that of their general surroundings to a greater or less degree, enabling the lizard to avoid detection and to steal upon its prey unobserved. The European Geckos make quite interesting and amusing pets; they are extremely pugnacious, loving a fight, and to rob each other, if possible, of their prey.

The Chameleon is one of the most extraordinary-looking creatures in nature; its neck is creased, its head triangular in outline, with a pyramidal top, and the bright, beady eyes are capable of looking in totally opposite directions at once. The long, pointed, prehensile tail is generally coiled round the branch on which the animal is resting, and the front and hind feet which terminate the slender arms and legs have the digits or claws divided into fore and aft sets, so that they clasp their supporting bough very much

Lizard



Lizard capturing prey

Chameleon on the watch

Bearded Chameleon, showing change of colour markings

after the fashion of some birds. The skin is soft, and its wonderful colour-changes are well known. The tongue is a most extraordinary weapon — long, fleshy, cylindrical, expanding into a curious, lobed, cup-shaped tip, and capable of being shot forth with extreme rapidity, the unfortunate insect victim becoming stuck fast to it by a viscid secretion. The lungs are of great size, and this enables the Chameleon to swell itself out and give vent to loud hisses in the curious manner it does when enraged. The colour-change is rapid and very remarkable, enabling the Chameleon so closely to resemble the colour of the leaves and branches amongst which it lurks awaiting its prey as to make it practically invisible at a short distance. The Chameleon leads a comparatively sedentary life, waiting and watching for the insects upon which it feeds to approach within range of the long tongue, rather than stalking its prey. Its movements are slow, cautious, and deliberate. The Common Chameleon has a fairly wide distribution, being found in Southern Spain, the North and South of Africa, in Asia Minor, Ceylon, and many parts of Hindostan. A large number of species or varieties, some very remarkable in appearance, inhabit the island of Madagascar. One of them, called the Rhinoceros Chameleon, has, in the male, an extraordinary horn-like projection at the end of the muzzle. The remarkable Three-horned Chameleon, the male of which has a long horn over each eye, in addition to the one at the end of the muzzle, is a native of Fernando Po.

The Skinks are very numerous, and inhabit almost every part of the tropics, some extending into more temperate zones. They are essentially land lizards, frequenting dry ground, and hiding in the sand and under stones. The Common Skink has short limbs and a long body, and a conical and pointed short tail. The neck is stout and the head small and wedge-shaped. It inhabits the western and northern parts of Africa, Senegal, Abyssinia, and Egypt. It loves warmth, and frequents the little hillocks of light sand that the wind accumulates at the foot of hedges which border cultivated land, and of the tamarisks on the edge of the desert. In such situations it delights to bask in the full rays of the burning tropical sun, rousing up to give active chase to any beetles or other insects that may come within range. The Blind-Worm, or Slow-Worm, the so-called Javelin and Glass Snakes,

do not belong to the snakes at all, but are lizards in which external limbs have either totally disappeared, or are only present in a rudimentary condition; in most the internal shoulder and pelvic girdles characteristic of the lizards can be traced.

The existing snakes may be conveniently grouped under three headings, two of which contain the poisonous species: (1) the Viperiform Snakes; (2) the Venomous Colubrines; and (3) the True Colubrines or Innocuous Snakes. Many snakes live a forest life, climbing the trees and moving from branch to branch; others live on the ground, rarely, if ever, taking to trees; a few lead a burrowing life, and some are water snakes, frequenting fresh water and the sea. All the marine forms are poisonous, belonging to the Venomous Colubrines.

With very few exceptions the snakes are covered with scales, which are true skin structures and are periodically shed. The presence of plates on the head, the arrangement and character of the scales on the upper and under surface of the body and tail, and their colour and ornamentation, are all points useful in the classification of these reptiles. We have seen that some of the amphibia and lizards are very snake-like in appearance, being destitute of external limbs, and some of the lizards have one of the lungs ill-developed, the other preponderating, as is the case in all snakes; while the Boas and Pythons have minute vestiges of hind limbs, scale-like or spine-like, close to the vent. But an examination of the internal organs, and especially of the bony framework of the snake's body, soon demonstrates the distinctness of the snakes from the lizards. The snakes and limbless lizards appear as examples of degenerate evolution, and as the descendants of reptiles which did not crawl on their belly but had in perfection those organs of locomotion that are rudimentary or absent in their descendants.

The venom of a snake is secreted by a gland on each side of the front part of the skull, which is close to the maxillary bones that support the long and more or less curved poison fangs. The duct of each gland leads either to a groove in the front part of the fang or to a canal in the tooth formed by the union of the sides of a groove, and in both instances the liquid poison enters the victim with the tooth, and some is left behind. Those snakes which have the first fangs of the upper jaw grooved along their

front do not differ very much in their shape from the common innocuous snakes, although some have the power of expanding their neck into a kind of hood; but those which have the hollow teeth are usually distinguishable by their large triangular head, short body, and very short tail. The venom or poison is a clear, pale yellow or straw-coloured fluid, and appears to be a pure solution of two or more poisonous proteins—which are the active agents—in conjunction with a small amount of an organic acid or colouring matter. According to C. J. Martin, there appears to be "only one fairly reliable treatment, that by serum therapeutics, the injection of considerable quantities of serum of animals which have been partially immunised by repeated doses of snake-venom. Unfortunately, this treatment will not often be available." Hundreds of natives perish annually from the bite of poisonous snakes, the Cobra and the dreaded "Krait" being responsible for the majority in India.

Few objects are more calculated to inspire awe than a large Cobra, when, with its hood erect, hissing loudly, and eyes glaring, it prepares to strike. The Cobras feed on small animals, birds' eggs, frogs and fish. They prefer taking their food at dusk or in the night, and are said to drink a great deal of water. The Cobra is oviparous, and the eggs, from eighteen to twenty-five in number, are about the size of those of a pigeon, with a white, tough, leathery shell. It is a most deadly snake, and its poison, when thoroughly inoculated, is quickly fatal. The number of deaths from Cobra-bite in India yearly is most appalling. The Cobras are the favourites of the snake-charmers, who render them temporarily harmless by extracting the poison fangs; but unless care is taken to remove the reserve fangs and germs, these deadly weapons are soon replaced. The snake has the power of raising its head, neck, and much of its body so that it balances as it were on its tail, swaying to and fro in a very graceful manner to the rhythmic motion of the snake-charmer's hands.

Australia has several very poisonous snakes, of which the Black Snake (*Pseudechis porphyriacia*) is the commonest. Equally fatal is the Brown-banded Snake (*Hoplocephalus curtus*), which frequents the plains; while the dangerous Death Adder (*Acanthophis antarcticus*) loves great warmth and frequents sandy places.

The Adder, or Common Viper, is the only poisonous reptile indigenous to Great Britain. Its favourite haunts are dry heaths, sandy wastes, open woodlands, and sunny slopes where rank grass and brushwood form a cover. It is very variable in colour, some specimens being nearly olive brown, others a dirty brownish yellow. The head is almost oval, depressed, and widening behind the ears. The gape of the mouth is great, and there are no teeth in the upper maxillary bones except the poison fangs. The neck is smaller than the back of the head, and the body increases in girth nearly to the middle, slightly diminishing to the vent, then becoming abruptly smaller and lessening to the extremity of the tail. These snakes are by no means uncommon in the New Forest, but as they are generally shy, slipping quietly away through the undergrowth when disturbed, they are not often seen. The real danger is the possibility when crossing the warm, dry heath lands of stepping upon one, or in sitting down in the long, rank grasses of placing the hand on one that may be concealed asleep, when it is very likely to turn and bite. Although the bite is rarely fatal, it is a dangerous experience, and produces a greater or less amount of pain and general constitutional disturbance. The Viper preys upon mice and small rats, so that it does good in helping to decrease the number of these vermin; and it also takes toll of the nestlings of those birds which build their nests on the ground. Of the African Vipers, the Horned Viper, the Puff Adder, and the River Jack Viper are familiar examples, frequently to be seen in zoological collections.

The Pit Vipers are so called from the presence of a little depression on both sides of the face between the eye and the nostril. Most of the Pit Vipers have large heads, which may be completely or not at all covered with large plates. To this group of very poisonous snakes, all of which have a canal in the poison fangs, the Rattlesnakes belong. They are readily recognised by the curious appearance of the end of the tail, which is made up of a number of horny, round, and flat pieces capable of making a sharp sound, not unlike that produced by a large grasshopper, by their friction during the rapid vibration of the tail. An average specimen of the Common Rattlesnake (*Crotalus durissus*) measures about 4 feet in length and 6 inches in girth, and the length of the nine rattles is about 2 inches. It lives upon rabbits, rats, and other

Boa Constrictor

Boa Constrictor resting on branch

Adder about to strike

Adder pursuing prey

small mammals, and is usually slow and rather sluggish in nature, rarely wantonly attacking. Other Pit Vipers are the Bushmaster of Guiana and Brazil, the Fer-de-Lance or Yellow Viper of Martinique, the Rat-tailed Serpent of St. Lucia, and the Brazilian Jararaca.

A familiar example of the Innocuous Colubriform Snakes is our Common English Grass Snake, which may attain to a length of 3 or 4 feet. It is a pretty, slender snake, very active and graceful in its movements, and quite harmless. When first captured and alarmed it has an unpleasant habit of voiding its excrement, which has a very offensive, musky odour that clings to the hands and clothes should they become soiled with it. It frequents sunny banks and heaths where the grass is high, and in the neighbourhood of a pond. It feeds upon frogs, newts, lizards, mice, and small fledglings. The female is oviparous, laying from sixteen to twenty eggs. It is easily tamed, and certainly learns to distinguish those who feed and regularly caress it.

An interesting and useful Colubride Snake is the Indian Rat Snake (*Ptyas mucosus*), which attains a length of 7 feet. It frequently enters dwellings in search of rats and mice, and if it would confine its attentions to these noxious vermin it would be indeed a welcome visitor, but it also has a liking for young fowls, and is always ready to bite.

The Pythons are the largest of the snakes, and are said to reach a length of 30 feet, though those generally seen are usually less than 18 feet in length, the greater size being rare. They have a wide geographical distribution, being found in the hottest parts of Africa, Asia, the Eastern Archipelago, and Australia, according to Gunther. The members of this family have the relics of hind limbs in the shape of bony spurs, and the tail is prehensile. They are not poisonous, but kill their prey by crushing it in the folds of their body.

The Boas form a sub-family of the *Pythonidæ*, and have the general configuration of the Great Pythons, though never attaining to such large size. They inhabit South America and lead an arboreal life. The Boa Constrictor is a very beautiful snake, and in captivity becomes quite docile and friendly. One which I kept for many years became a great pet and showed considerable affection for myself and my wife. When caressed by us it would rub

its head gently against our faces in the most affectionate manner, but would draw away and hiss at strangers. The skin was cast periodically, and for a day or two before this took place the Boa appeared unwell and rather morose, but it quickly regained its normal good temper and health once the old skin had been sloughed off.

It would be impossible here to enter into a detailed account of the ancestors of the existing Reptiles; their fossil remains have been found in the Permian deposits, and in those of the consecutive ages to the Pliocene, but the Trias, Lias, and Oolitic strata in the Old World, and the Cretaceous strata of the Old and New Worlds, contain the greatest number, and the structural affinities of the extinct kinds with the recent, and with fish and birds, are very remarkable. During the Mesozoic or Secondary Period of the earth's geological history we find the reptiles occupying the place in the economy of Nature which has since been usurped by the mammals and birds. This Secondary Period has been aptly called the Age of Reptiles, and during that period there existed gigantic forms which were vegetable feeders, as ponderous as the extinct ground-sloths of the later Tertiary Period; there were slim, active carnivora, and great sea reptiles with paddles formed solely for swimming, and there were true flying reptiles, veritable dragons of the air, with well-developed wings supported by bones of a texture and construction now typical of the birds.[1]

[1] For a popular introduction to this fascinating subject the reader should consult the pages of Sir E. Ray Lankester's "Extinct Animals"; the "Guide to the Fossil Reptiles, Amphibians, and Fishes," of the British Museum (Natural History), price ninepence; and Dr. Hans Gadow's volume of "Amphibia and Reptiles," in the Cambridge "Natural History."

CHAPTER XIX

AVES: THE BIRDS

Birds are distinguished from all other animals by their clothing of feathers. They differ conspicuously in many other ways from the majority of vertebrates, but these differences are not altogether peculiar to them. Thus, we may describe a bird as a vertebrate creature capable of flight, but there are certain mammals, bats, and in a modified degree flying squirrels, which also possess this power; while some species of bird, the apteryx, ostrich, cassowary, penguin, cannot fly at all. Birds produce their young from eggs, but this is also the case with fishes and many reptiles. The hard, sheathed bill of a bird may be said to be a distinguishing feature, but turtles also have beaks, and so has the duck-billed platypus, an animal belonging to the mammals; while the nest-building habits of birds are shared by many small mammals such as mice and lemurs, and several of the fishes. But in the possession of feathers the class Aves stands alone; and this characteristic is peculiar to all birds, whether or not they possess the power of flight.

To the casual observer no two creatures, perhaps, appear more dissimilar than an agile, graceful bird and a sluggish, cold-blooded reptile. Yet a bird is in reality only an extremely modified reptile, and still plainly shows traces of its ancestry in the scales of the foot, in the claw on the thumb of the wing, present in certain species, and in the formation of the beak; while in the skeleton of a bird and of a reptile there are many points of resemblance.

Both birds and reptiles produce the same type of egg, and the development of the young within the shell is at first almost identical. The bird-like character of a young chick is not apparent until the sixth day, and the horny cap at the tip of the bill of an unhatched chick, popularly called the "egg-tooth," which it uses to break its way out of the shell, is also possessed by certain reptiles. Indeed, birds and reptiles have so many points in common that

Professor Huxley united the two classes in the *Sauropsida*, one of his three primary divisions of the Vertebrata.

Birds and mammals are related to one another only inasmuch as they have both sprung from a common ancestry—the reptiles—and resemble each other only in being warm-blooded, for although birds and mammals are both derived from reptiles the two classes of animals have developed on totally different lines. While the birds gradually acquired those characteristics which enabled them to conquer the air, the evolution of the mammals tended more and more to fit them for a terrestrial life.

But while it is certain that birds have come from a reptilian stock, it is not possible to say from which particular forms they are descended. The direct line of descent is lost in obscurity, for there is very little rock record of prehistoric birds. The fossil remains of the Archæopteryx, the oldest known bird, are distinctly reptilian in many ways; two specimens of this curious bird are in existence—one in the Natural History Museum, and the other in the National Collection of Berlin, both specimens having been obtained from the lithographic slate of Solenhofen in Bavaria. The Archæopteryx was about the size of a large pigeon; its head was short, had no beak, and both jaws were provided with teeth; it had three distinct clawed fingers, and a long-lizard like tail bearing a double row of feathers. In writing of the Archæopteryx, Sir E. Ray Lankester says:[1] "It cannot be said that this ancient extinct bird goes far towards connecting birds with reptiles, but in the possession of separate claw-bearing fingers, a long bony tail and teeth, in the apparent want of a beak, it does come nearer to lizard-like reptiles than does any other known bird." Although the Archæopteryx is the oldest bird of which we have any record, it is certain that other more primitive forms must have existed previously on the earth. At exactly what period in the world's history the first reptilian vertebrate became a "bird" can only be a matter of conjecture; we can only be certain that the transformation came about in very remote times, in all probability before the advent of the Jurassic Period in which such strange birds as the Archæopteryx flourished.

Birds in their structure show a remarkable degree of uniformity, which has been necessarily brought about by the requirements

[1] "Extinct Animals." Sir E. Ray Lankester.

of the aerial life they normally lead. The fore-limbs are always modified into organs of flight, even when, as in some cases, they are merely rudimentary; and while the bones of a bird's wing correspond in a general way to the bones of the fore-legs of a mammal, as might be expected, the bones, the joints and muscles show considerable modification as compared with the fore-limbs of other animals. The problem of flight, that has only of recent years engaged our attention, was solved by Nature in various ways before man ever came into existence. The bird, the bat, the insect, are all so many examples of efficient flying machines, each perfect in its way, though differently constructed, and man has yet a long way to go before his mechanical constructions approach in proficiency any one of these natural aeroplanes.

A bird when it flies has to work against its weight, hence the muscles employed to pull down the wing against the air, and so raise the body, are remarkably large and strong. The principal muscle used in this manner is the great pectoral muscle attached to the keel or ridge (which is a distinguishing feature of the breast-bone of a flying bird), and inserted into the humerus or arm-bone; and the bird opens out its wing by straightening the elbow and wrist-joints, and folds it by bending the elbow and bringing forward the wrist-joints.

The feathers which clothe the bird correspond in their nature to the scales of reptiles and the hairs of mammals, and are modifications of the cells of the *epidermis*, or upper skin, and the *cutis*, or under skin. The feathers are not all of one kind; the two most familiar types are the *contour* feathers, which form the outer covering of the bird, and the *down* feathers, which form a soft, dense underclothing corresponding to the under-fur of the mammals.

A *contour* feather consists of a quill, or *calamus;* a shaft, or *rhachis;* barbs, or *rami;* and barbules, or *radii*. The shaft is a continuation of the quill, the whole forming the axis of the feather. The quill is a hollow cylinder within which is a series of oblong, hollow cells, containing the nutrient material, or pulp, from which the feather is derived; it forms the lower part of the axis, the base being inserted in the skin. The shaft of the axis is solid, and bears on each side a broad, elastic web, made up of a series of narrow, tapering plates, or *laminæ*—the barbs—set obliquely on the shaft. The barbs, in turn, bear a double row of smaller pointed

laminæ known as barbules, which serve to interlock the barbs, forming a surface which is able to withstand the rush of air, and is practically impervious to water. The shaft and the barbs together form the vane or *vexillum* of the feather. The contour feathers of the majority of birds bear two vexilla; the second, termed the *after-shaft*, is usually a smaller and more delicate edition of the main shaft, from the base of which it springs, but in some species of the ostrich tribe and a few nestling birds the main shaft and the after-shaft are equal in size.

The *down* feathers differ from the contour feathers. The barbs are very long, soft and fragile, and are deficient in the interlocking barbules. In many cases, instead of being arranged in a double row down each side of a shaft, the barbs spring in a tuft from the top of the quill. When the shaft is present it is short and weak. Game birds, pigeons and hornbills have no down feathers.

Powder-down feathers, which occur in tufts or patches in certain birds of prey, in parrots, and more especially in the heron tribe, are down feathers of an extremely friable nature, which are constantly breaking up at the tips into fine powder, often imparting a curious bloom to the plumage of the bird.

Filo-plumes, or thread feathers, are long, hair-like feathers growing in small clusters at the base of the contours. In some birds they grow very long and project in tufts beyond the contours. In the cormorants these filo-plumes show as large white patches on the neck and thighs.

A bird's feathers, except in the penguins, are not evenly distributed over the entire surface of the body, but grow in well-defined rows or tracts with bare spaces in between them, which are, however, in most birds covered with down. The contour feathers covering the head and body overlap one another much in the same way as do the scales of fishes and reptiles; and the large flight feathers which fringe the hinder border of the wings are arranged in such a manner that, when the wings are extended, the feathers overlap one another laterally, and the free edges face outwards.

The varied colours of the feathers, to which many birds owe their wonderful beauty, are due either to the presence of actual pigment, to pigment overlaid with colourless structures, or to

iridescence caused by the light falling on the surface of the feather, which may be ridged, polished or pitted, and beneath which lies a blackish pigment, so that the surface acts as a series of prisms. But, alas,[1] "this fatal gift of beauty has from earliest times subjected the wearers to a rigorous persecution, not only at the hands of savage races, but of peoples boasting themselves civilised, among whom women have always been the worst and most heartless offenders. On account of the ceaseless persecution to which these defenceless creatures have been subjected to meet the demands of fashion, savage and 'civilised,' many species have become wiped out of existence, and of many more the doom is sealed; the more beautiful of the humming-birds and the birds of paradise, for example, will, in another decade, have ceased to exist!"

At the base of the tail feathers birds have, as a rule, an oil-gland, or *uropygium*, in which is secreted a considerable quantity of clear oil. This oil is generally believed to be used by birds to lubricate their plumage; they are said to press out a small quantity with their beaks, through which they afterwards draw the feathers separately. This fact has, however, lately been disputed by several ornithologists, as the beaks of many birds are so constructed that it is impossible for them to perform the operation, and it has been suggested that possibly the gland may act as a scent gland.

Existing birds are divided into two separate orders: the first, the *Carinatæ*, includes all the flying birds; and the second, the *Ratitæ*, the running birds—ostriches, cassowaries, etc. A third order, the *Saururæ*, comprises the extinct, lizard-tailed birds.

The breast-bone, or *sternum*, of a bird is large and broad, and more or less convex in shape. In all flying birds it is provided with a ridge or keel (*carina*), to which is attached the powerful flight muscles by which the wings are moved. The keel varies in size according to the power of flight of the particular species—thus, swifts, certain petrels, and humming-birds have a remarkably deep keel on the breast-bone, while in some of the rails and certain extinct birds, such as the New Zealand goose and the dodo, the keel is hardly discernible. The running birds—ostriches, emus, etc.—have no keel to the sternum, and are termed raft-breasted birds (*Ratitæ*).

A bird's skull is remarkable for the large size of the eye sockets,

[1] W. P. Pycraft.

which are divided one from another merely by a thin bony partition. The nostrils may be rounded or slit-like, and may be divided by a *septum*, when they are termed *impervious*, or there may be no division between them, when they are termed *pervious* nostrils. The beak is covered with a horny sheath, which is composed of one or more pieces; it varies in texture, and sometimes has curious outgrowths, as in the sheathbills and hornbills. The beak varies considerably in length and form. It may be fine and slender, short and thick, hook-shaped, wedge-shaped, spoon-shaped, straight and flat, curved upwards or downwards, adorned with knobs, horns, or shields, and the edges may be notched, serrated, lobed or festooned. The many different and peculiar shapes of the birds' bills have been gradually brought about by the requirements of the particular species, and, broadly speaking, are intimately related with the nature of their food, though this does not altogether account for the grotesquely shaped bills which many birds possess.

The bones of the skull become completely united early in life, showing no trace of their original division, and the skull is joined to the neck by a single hinge, a *condyle*, as is the case in the reptiles.

The backbone of a bird differs from that of a mammal. The neck division is remarkably flexible, and the vertebræ of which it is composed articulate one to another by saddle-shaped surfaces, and vary in number from eight to twenty-three. In the middle, or thoracic, portion the vertebræ in many instances are fused together into a solid bar of bone. The tail, in all living birds, has very few vertebræ. They number from eight to ten, the last one being very large, and from its curious shape called the "plough-share-bone," or *Pygostyle;* to this are attached the tail feathers. It is an interesting fact that in very young birds this bone is made up of several distinct vertebræ, which later on become fused together, showing that originally birds must have possessed longer caudal appendages, marking their descent from the lizard-tailed birds of bygone ages.

The foot of a bird is encased in a scaly covering, and is very rarely feathered. The number of toes (digits) in the foot may be three or four; a fifth toe is never present, while in the ostrich the number is reduced to two. The foot shows considerable modification in different species. Birds frequenting forests and leading a strictly arboreal existence, such as parrots, cuckoos,

bee-eaters, rollers and woodpeckers, have curiously formed feet, somewhat resembling the feet of a chameleon ; perching birds have the hind toe long, making the foot a convenient grasping organ ; and in water birds the digits are united by a web. The arrangement and length of the digits vary considerably in different kinds of birds.

Many birds have the tongue but feebly developed, in others it is encased in horn ; some, however, the woodpecker for instance, have a powerful, well-developed tongue, which is used for seizing insect prey, and is darted out with great rapidity. On the other hand, the pelicans are quite tongueless.

Birds, like all warm-blooded creatures, have the heart divided into two separate halves, each of which is again divided, forming altogether four cavities—two upper chambers, or auricles, and two lower chambers, or ventricles.

The respiration of birds differs from that of other vertebrates. The lungs are not freely suspended, but are attached to the roof of the body-cavity, and the air is not drawn into the lungs and again expelled, but drawn through the lungs, as it were, into the air-sacs—membranous chambers—of which there are five pairs attached to the upper part of the body-cavity. In these air sacs the air is stored not only for purposes of respiration, but to regulate the temperature and to serve as a reserve supply to increase the volume of sound during long-sustained singing. Some birds, in addition, possess curious air-pouches in the neck which can be inflated or deflated at will. These, as they are possessed by the male bird only, must be regarded as sexual adornments. The adjutant storks, the emus, and the bustards are distinguished in this way. Not only are birds provided with these numerous air-sacs, but even the bones of the majority are hollow and act as receptacles for air, so that a bird is practically clothed with air ; yet, strangely enough, this pneumaticity does not appear to be of any particular advantage to the bird in its flight, as some of the poorest fliers are also the most permeated with air.

The digestive system of birds is peculiar. Most birds swallow their food without any attempt at mastication, and it passes into the gullet, which is dilated into a crop. Here the food is stored for awhile and softened by means of water and saliva in conjunction with the body-heat. It then passes on into the stomach, which

is divided into two parts; the walls of the lower portion or "gizzard" are extremely muscular and usually very rough. In birds that feed on grain, etc., the walls of the gizzard are provided with a pair of thick, rough pads which, in conjunction with a quantity of small stones swallowed by the bird, form a very complete apparatus for crushing and grinding up the hardest food. Flesh-eating birds and those which live on fruit or insects have the gizzard but little developed.

The migration of birds is one of the most fascinating of all phases of bird life. The coming and going of the feathered legions has been observed and commented on by naturalists and philosophers of all ages, and yet, to-day, we really know but little about it. The actual forces that determine the movements of migrating birds still remain something of a mystery, and of the exact routes the travellers follow we have no very definite knowledge. To-day the flocking together of immense numbers of birds, and their orderly, concerted movements as they wing their way over land and sea in their long periodical journeys, may be witnessed as in years long gone by. "The hawk that stretches her wings towards the south is as familiar to the latest Nile-boat traveller or dweller in the Bosphorus as of old to the author of the Book of Job. The autumnal thronging of the myriads of water-fowl by the rivers of Asia is witnessed by the modern sportsman as it was of old by Homer. Anacreon welcomed the returning swallows in numbers which his imitators of the colder North, to whom the associations connected with it are doubly strong, have tried in vain to excel. The Indians of the fur countries in forming their rude calendar name the recurring moons after the birds of passage, whose arrival is coincident with their changes. But there is no need to multiply instances. The flow and ebb of the feathered tide has been sung by poets and discussed by philosophers, has given rise to proverbs and entered into popular superstition, and yet we must say of it still that our ignorance is immense."[1]

For the sake of convenience birds are generally divided into two classes—"resident" birds and "migratory" birds; but actually it is not possible to draw a hard and fast line between them, for to a certain extent almost all birds are migratory—that is to say that although certain species, such as robins, thrushes,

[1] Professor Newton.

and titmice, are resident with us throughout the year, those we see are not always the same individuals. As cold weather sets in, the birds that have passed the summer months with us move southwards, but their places are filled by others that come flocking in from colder northern lands. It is noticeable, too, that towards the end of the breeding season the birds of a particular species may suddenly become much more numerous, but the influx does not last long, the new-comers passing onward to fresh haunts. These birds are termed "partial" or "gipsy migrants." Besides these resident and roving species we have our regular summer and winter visitors that stay on our shores for a longer or shorter period, some for many months; others, true birds of passage, pause but a short time on their way north or south. The swallow, the cuckoo, the nightingale, that come in the springtime and stay and breed in temperate regions during the summer, wing their way in the autumn to warmer climates; while the fieldfare, the redwing, the jack-snipe, flock in from the north as cold weather sets in. All birds breed in the colder regions of their migration; then, when the young are sufficiently advanced, when food becomes scarce, and the nights grow cold, they automatically move farther south. The tendency of all migrating birds, apparently, is to take a course due north or south: thus, the swallows that have reared their young in northern Europe migrate to Africa; those which have nested in Northern Asia pass on to India and Burma, or still farther south to Australia and New Zealand. North American swallows migrate to South America, to return in the following year to their usual summer haunts.

The manner of the migration varies with different species. Some birds gather together in enormous flocks, some journey in small companies, others appear to fly in pairs or even singly, though this is not very usual. The longest journeys are evidently performed at night, and at certain times vast hosts of birds may be heard passing overhead in the darkness; and on dark, cloudy nights many are killed by dashing themselves against the blinding lights of the lighthouses along the coasts."[1] Two instances given by Gätke show the extent of these visitations:—

"From ten o'clock on the night of October 28th, 1882, to the next morning, goldcrests eddied thick as flakes in a heavy snowfall round the lighthouse on the little island of Heligoland;

[1] W. P. Pycraft.

on the morrow they literally swarmed over every square foot of the island; and twelve months later hawks in myriads thronged to its bright beams for four nights in succession, accompanied by starlings in hardly fewer numbers.

"Only where the lighthouses show a red light do the migrants pass unharmed, the ruddy beam failing to exert any influence over them."

One cannot help wishing that all lighthouses could be fitted with perches and other simple devices, which have proved, in the two or three cases where they have been adopted, of the greatest value in affording the birds a temporary rest, and diminishing the mortality caused by their dashing themselves against the windows.

One curious fact about migrating birds is that in many cases the young ones and the adults do not make the journey together. As a rule the young birds start first; and it is difficult to understand how it is possible that they can find their way over a route they have never travelled before. Among the cuckoos this order is reversed, the old birds leaving the country several weeks before the young ones are fit to make the journey.

Many birds have the most curious and interesting courtship habits. At the commencement of the breeding season the males do their utmost to outshine one another and win the admiration of the hen birds. Brilliant plumage, at this time of the year in its greatest beauty, vocal accomplishments, strength and acrobatic dexterity, are all employed by different species to attract the favourable attention of the desired mate, who in many instances appears to show the greatest indifference to these performances. The blackbird may be noticed in the springtime strutting about with a self-conscious air in his glossy courting suit—bowing, flirting and spreading his tail, and trying to show himself off to the best advantage; and the too familiar house-sparrow goes through the most absurd antics as, with drooping wing and upraised tail, he struts round the little hen. But these exhibitions are nothing in comparison to the extraordinary performances which some of the more remarkable of the birds indulge in during the courting season. The great Australian bustard (*Eupodotis australis*) distinguishes himself by swelling out his large throat-pouch, going through at the same time a series of grotesque movements. Dr. Murie describes the proceedings of this bird as follows:—

"The premonitory symptoms observable when the bustard is about to exhibit himself in the pride of lust : . . . is a slight swelling of the infra-mandibular portion of the throat, while the head is thrown upwards. Immediately afterwards the neck swells, and the feathers of the lower parts concomitantly bulge out and descend gradually downward in the form of a bag, oftentimes nearly reaching the ground. If the paroxysm is a strong one, then the tail is shot upwards and forwards over the back, the rectrices (tail-feathers) coming almost in contact with the neck.

"In this particular attitude, with bloated neck, hanging baggy chest, elevated tail, and stiff, stilt-like legs, the creature struts about in a somewhat waddling manner, the elongated pouch swaying to and fro. The feathers of the throat start out on end; those of the depending sac are also raised, but less upright.

"The acme of inspiratory effort and strange attitude attained, the bustard begins to snap the mandibles together in a loud manner, and utter a series of cooing sounds for a short interval of time."

No less remarkable is the display of the frigate-bird, described by Dr. C. W. Andrews. "About the beginning of January the adult males begin to acquire a remarkable pouch of scarlet skin beneath their throats. This they can inflate till it is nearly as large as the rest of the body, and a dozen or more of these birds sitting on a tree with outstretched drooping wings and this great scarlet bladder under their heads are a most remarkable sight. When a hen bird approaches the tree the males utter a peculiar cry, a sort of *wow-wow-wow-wow*, and clatter their beaks like castanets, at the same time shaking the wings."

Some birds in the mating season hold regular contests in dancing, or tournaments, to show their prowess, the hen birds standing aloof, yet watching the display from a distance. The ruffs, the male birds of a species of sandpiper (*Pavoncella*), are noted for their pugnacious behaviour during the mating period. They are adorned at this time with a great ruff of feathers round the neck, and two long tufts of feathers on the head, called the "ears." When engaging in combat the ruffs are erected and stand out like great frills round the necks of the birds, who conduct their fights with a curious display of ceremony. Two rival birds stand facing each other with ruffs extended, and heads bent down so that the tip of the beak rests upon the ground. For a short time they remain

in this position, motionless, then suddenly both spring into the air and strike at one another with their feet. These manœuvres are repeated again and again until one or both combatants are tired; if, however, they grow too excited they lose their tempers, and, discarding their regular rules of battle, each bird tries to seize its opponent by the beak and belabour it soundly with its wings.

Blackcocks, too, indulge in the most amazing sparring matches when courting the grey hens, the tournaments taking place in the early hours of the morning before the arrival of the hens upon the scene. When a grey hen appears the various duels cease, and the cocks go through all sorts of ridiculous antics, flinging themselves into the air and dancing about with outstretched wings while they utter loud, hoarse cries, each bird doing his best to scream more loudly and dance more madly than his rivals and so gain the favour of the demure grey hen.

The habit of dancing to win their mates or impress their rivals is not uncommon among birds; one of the most curious examples is seen in a small South American bird called a "Manakin." Its performance has been described by Mr. Nutting, who says: "The natives call this bird the 'bailidor,' or 'dancer,' but it was not until I had been in the region for some time that I understood why it was called by that name. One day, when hunting through the dense forest, the profound silence was suddenly broken by the regularly repeated note of "*El Bailidor*," and softly making my way to the spot, I witnessed one of the most remarkable performances it has ever been my lot to see. Upon a bare twig which overhung the trail at a distance of about four feet from the ground, two male 'bailidors' were engaged in a 'song and dance,' an act that simply astonished me. The two birds were about a foot and a half apart, and were alternately jumping about two feet in the air, alighting exactly upon the spot whence they jumped. The time was as regular as clockwork, one bird jumping up the instant the other alighted, each bird accompanying himself to the tune of *to-le-do—to-le-do—to-le-do*, sounding the syllable *to* as he crouched to spring, *le* while in the air, and *do* as he alighted. This performance was kept up without intermission for more than a minute, when the birds suddenly discovered they had an audience, and made off."

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These strange performances are usually confined to the male birds, but in some cases the female joins in the dance. Mr. Nelson, in his "Birds of Alaska," describes the behaviour of a pair of stately cranes, who hopped and bowed and pirouetted together in the most ceremonious and ridiculous fashion; and similar exhibitions have been witnessed in several different species of bird by reliable observers. In certain species the rôles of the male and female are reversed, and the female bird courts the male; when this is the case the female is always the finer and more brilliantly coloured of the two.

In their nest-building habits birds show a remarkable degree of diversity. Many, indeed, do not build nests at all, but simply lay their eggs on the bare ground, usually in a slight depression; others collect a few sticks, dried leaves, or pieces of seaweed, according to their kind, to form a rough sort of bed; some utilise holes in rocks, in the ground, in hollow trees, as nurseries; some dig holes for themselves in the earth with the aid of beak and claw; while amongst those birds that build actual nests the nests vary from a rude, shapeless jumble of twigs, grasses or other odds and ends, to the most beautiful and elaborate structures. All manner of materials, too, are used in making the nest—moss, twigs, grass, wool, hair, cotton, feathers, mud, lichen, cobwebs, and the rootlets and seeds of various plants.

Amongst the birds that nest in burrowed holes are the sand-martin, bee-eaters, kingfishers, some of the penguins and the puffins; the latter habitually breed in rabbit-holes on the edge of cliffs, but, if these are not available, will burrow for themselves or deposit their eggs in crevices of rocks; holes in trees are used by the owls, wrynecks, and woodpeckers. Simple ground-nests are made by swans, ducks, geese, waterhens, and corncrakes; platform nests are constructed in trees, rocky ledges, or on the tops of buildings by turtle-doves, ringdoves, eagles, cranes, and storks. Swallows, flamingoes, and tree-creepers use mud to build their nests; thrushes use mud in conjunction with other materials, such as moss, roots, and grass. Beautifully woven, cup-shaped nests are made by chaffinches, redstarts, and goldfinches; the nests of wrens, water-wagtails and some of the tits are domed, one of the most beautiful examples being the work of the long-tailed tit (*Acredula caudata*). This nest is made of moss and wool bound together with spiders'

webs; on the outside it is adorned with lichens, and internally it is lined with soft feathers. In shape the nest is nearly oval, and the entrance is a small hole on one side; it is usually placed amidst the small branches of trees or thick bushes, and the framework of the nest is so firmly interwoven with them that the structure cannot be removed without damage unless the surrounding branches are taken too. Although it is such a wonderful and striking little nursery it is not at all noticeable as it rests in its natural position, the lichen with which it is encrusted causing it to harmonise perfectly with its surroundings.

Humming-birds make the most charming little purse-like nests of soft felt woven almost entirely of cotton-down. The tailor-bird deftly stitches the edges of a leaf with vegetable fibres, or even with manufactured threads if it happens to find any about, and fills the little pocket thus made with softest cotton-down. Many species suspend their nests from branches of trees or amongst reeds and rushes; a beautiful example of this type of nest is made by the little golden-crested wren, the smallest of all British birds. Soft green moss and wool are used in its construction, interwoven with long grasses and spiders' webs, while inside it is finished off with a few small feathers. It is usually suspended from the smaller twigs of a spreading branch of a larch, fir, yew, or cedar tree.

In many cases the female undertakes the entire building of the nest as well as the brooding and rearing of the young, but these duties are very often shared by the male bird, and in some instances he has the whole burden of providing for his offspring thrust upon him by his mate, who considers she has accomplished all that is required of her when she has laid the eggs, and so departs, leaving them to his sole care.

For the incubation of their eggs and upbringing of their young most birds prefer privacy, and the greater number of nests are built singly; some species, however, build in colonies. Swallows, rooks, herons, and the majority of the sea-fowl form large breeding communities, but, although the nests are often closely packed together, each bird, or pair of birds, has a nest, or particular site, of its own. Two species of birds, however, have adopted an even more sociable arrangement; the grosbeak and the weaver-bird of Africa form large colonies in which all the members combine to

erect a huge, umbrella-shaped mass of straw and sticks in the branches of trees, which often contain as many as three hundred nesting holes, forming a regular "bird-warren."

Instances of birds occupying the same nest are rare, but the emus, cassowaries, and ostriches are known to follow this practice, several females depositing their eggs in the same depression in the ground. More than thirty eggs are sometimes deposited in a single ostrich's nest, and their incubation is undertaken by one cock bird, the hens only occasionally sharing in the duty.

In most cases the necessary warmth for the incubation of the eggs is supplied by the brooding of the parent bird, but in tropical regions certain birds brood their eggs only at night, leaving them by day buried in the ground under the hot rays of the sun; this course is pursued by the small Egyptian plover (*Aegyptius pluvialis*), and the ostriches inhabiting the hottest parts of their breeding range.

The *Megapods*, or "mound builders," a family of shy terrestrial birds, chiefly confined to the Australian regions, have relinquished brooding altogether, and leave the hatching of their eggs to the natural agencies of the sun and the warm earth. Those of one species (*Megacephalum maleo*), inhabiting the hilly districts of North Celebes and the Sanghir Islands, come down to the beaches in the breeding season and scrape holes in the volcanic sand just above high-water mark for the reception of their eggs. The holes are three or four feet deep, and from four to five feet in diameter, one hole being the joint property of several birds, who deposit their eggs therein, numbering from two to eight, at intervals, it is stated, of from ten days to a fortnight. The eggs as they are laid are covered with the sand and left to hatch of themselves, and the young birds, which emerge from the shell fully feathered, soon push their way up through the loose soil and run away inland. The brush turkey of Eastern Australia has similar habits, but here a regular mound of earth and decayed leaves is formed by several females, sometimes reaching six feet in height, and measuring from twelve to fourteen feet in diameter at the base. This mound is hollowed out like a cup, and the eggs, which usually number from twenty to thirty, are placed in it in successive circular layers, the small ends pointing downwards, each layer being covered in with earth. These mounds are usually found in

the midst of dense foliage, where the sun's rays cannot penetrate, and when once made are used by the birds year after year; that they last for an exceedingly long time is evident, Gilbert having found one with a tree a foot in diameter growing from the middle.

Although very conservative in the choice of site, building material, and the manner of making the nest, birds may be said "never to do anything invariably," and they will often depart from the recognised custom of their family or species, in some cases apparently from sheer eccentricity, but more usually to adapt themselves to altered circumstances. Thus, though gulls as a rule nest on the ground, they have been known to build in quite high trees. Rooks, that habitually use dried sticks and twigs in their building operations, have been observed, when these were scarce, to substitute for them odd lengths of wire from refuse heaps in the vicinity of the rookery; and the robin and the titmouse are both noted for the extraordinary places they often choose in which to lay their eggs.

Great Bustard

Ruff challenging in mating season

Head of Cassowary

Cassowary

CHAPTER XX

THE BIRDS (Continued)

The order **Ratitæ** includes six families of birds—Ostriches or *Struthiones*, Rheas or *Nandus*, Cassowaries and Emus or *Megistanes*, Kiwis or *Apteryges*, Moas or *Dinornithes*, and Rocs or *Aepyornithes* —the last two families being extinct.

The *Ratitæ* are a primitive group of birds characterised by having no keel to the sternum; greatly reduced wings, useless as flying organs; feathers having free barbs, not held together by hooked barbules; the absence of the curious "ploughshare" bone at the end of the tail; and the construction of the skull, which differs from that of all flying birds, with the exception of the tinamou.

They have been described by Professor W. K. Parker as "overgrown, degenerate birds that were once on the right road for becoming flying fowl, but through greediness or idleness never reached the 'goal'—went back, indeed, and lost their sternal keel, and almost lost their unexercised wings." The generally accepted theory is, however, that the *Ratitæ* are descended from birds which once possessed the power of flight, but lost it in consequence of the abundance of food and scarcity of enemies in the areas they frequented, which rendered flight unnecessary; and that the small wings of the ostrich and the mere vestiges seen in the cassowary, emu, and kiwi are degenerate and not incipient. The fact that every degree of the degeneration of the wing can be traced down to its entire disappearance in certain extinct moas is brought forward in proof of this theory by W. P. Pycraft, who argues that if this is not a case of degeneration, "we must suppose the wings (of the present types of Ratitæ) to have developed from nothing; and this would imply that the earliest birds were descendants of creatures wherein the fore-limb had disappeared, and in time reappeared in the form of a minute useless organ,

such as is seen in the apteryx, and thence had continued to develop, attaining its climax in the wings of the eagle, condor, and albatross."

Naturally, birds that cannot fly run far greater risks of extermination than those that can escape on the wing from their enemies, and this danger became greater as soon as man appeared upon the scene. The giant Rocs and Moas were apparently hunted out of existence by the natives of New Zealand and Madagascar in recent times, for there is evidence that some of these birds were still in existence some two hundred years ago. A like fate has overtaken flightless birds belonging to other families, The most notable examples are the Dodo—a bird allied to the pigeons, found living at the end of the sixteenth century on the island of Mauritius, when it was rediscovered by the Dutch—which was wiped out of existence by the pigs imported by the invaders; and the Great Auk, or "Gare-fowl," a bird related to the guillemots and razorbills, that used to be abundant in the northern seas, and habitually bred on the island of St. Kilda. This bird, which was apparently very helpless and stupid, and from its ill-developed wings quite incapable of flight, was killed in wholesale fashion by sailors for the sake of its flesh and feathers, and, as its rate of reproduction was very slow, it was quickly exterminated. The last survivor, it is believed, was captured in 1834.

The Rocs and the Moas were huge, ostrich-like birds, with, in most cases, very stout and long legs and small heads. The Roc produced eggs which were extraordinarily large in proportion to its size, some having been discovered measuring thirteen inches by nine and a half inches. From the size of the Roc's egg it was at one time imagined that the bird itself must have been proportionately gigantic, and this probably gave rise to the wonderful stories of the giant Roc of the Venetian traveller, Marco Polo, and of the Arabian Nights. As a matter of fact, the largest known species of this bird probably stood about seven feet high, not so large as some of the New Zealand Moas, whose height is estimated to have been twelve feet.

Very nearly related to the extinct Ratitæ are the curious little Kiwis of New Zealand. They are comparatively small birds, the largest member of the family, the Large Grey Kiwi (*Apteryx haasti*), being only two feet high. The neck and feet are propor-

tionately shorter than in the ostriches and cassowaries, the beak is long, weak and tapering, and the feathers which clothe the body are hairlike. The wings are exceedingly small and completely hidden, so that the bird appears to have none at all, and from this peculiarity it has been given its family name, *Apteryx*, which is derived from two Greek words signifying " not " and " a wing." Kiwis are very shy birds. By day they hide in burrows in the ground, or amongst the rocks or roots of the trees in the wooded country or the hills which they frequent, rolling themselves almost up into a ball. At night they become more active, and run about very swiftly on their sturdy little legs, taking great strides, and holding themselves in an oblique position with the neck stretched out and the head well forward. They have a curious way of resting upright, and partly supporting themselves with the beak, which is used as a third leg, the tip resting on the ground. If annoyed, the Kiwi will draw up one foot and give a quick downward kick with considerable force. Its food consists chiefly of worms, for which it probes in the earth with its long bill, making the while a curious sniffing noise as if it were trying to find its food by smell, At night the Kiwi gives utterance to a loud, whistling note, and if disturbed during the daytime it emits a kind of growl. It is said, too, to be much given to yawning, opening its beak to the widest possible extent in the most ridiculous manner. The bird lays an enormous egg in proportion to its size ; two eggs are usually laid, and the male bird, which undertakes the incubating, is not able entirely to cover them.

The Emus and the Cassowaries are large ostrich-like birds, with quite rudimentary wings. The plumage is hairlike, and each contour feather appears to be double, the after-shaft being almost equal to the main shaft, and there are no plumes on the wings or tail.

Cassowaries are confined to Australia, New Guinea, Ceram, and some of the adjacent islands. They are distinguished by having a large, horny helmet on the head, which has no feathers, and the neck, which is also bare, is usually ornamented with pendent wattles. They are striking-looking birds ; the plumage is glossy black, and the neck and wattles are variously coloured in different species. One which inhabits the Aru Islands has a greenish-blue head, a blue neck marked on the back with red, a black

helmet and purple wattles. Another, found in the same islands, as well as in New Guinea, has the helmet coloured black, green and yellow, the head grey, the neck orange, red and blue, flesh-coloured wattles, and a yellow streak running from the beak across the head. Cassowaries run very swiftly, though somewhat heavily, and can take tremendous leaps over obstacles. They are able to swim with ease, and will often cross rivers in the wet season. Normally they are forest birds, but they often come out into the open country, particularly where creeks and watercourses are found.

Emus are very much like cassowaries in their habits, but they frequent more open situations, sandy plains and forest land, where the vegetation is not dense. They are bigger birds than the cassowaries, and the head is feathered and has not the curious helmet. They range throughout Australia and some of the adjacent islands. The Common Emu (*Dromæus novæ-hollandiæ*) of Eastern Australia is almost as big as an ostrich; it is dark grey in colour, with a somewhat mottled effect owing to the black tips of the feathers. Young birds before they gain their adult plumage are striped with black and greyish-white on the back, while the head and under-surface are spotted. This colouring is protective, and renders the young Emu chick inconspicuous when crouching among the grasses. Both Emus and cassowaries are monogamous, though after the breeding season the birds often herd together in small companies. Their food consists of herbage, roots and fruit. They have keen sight, can run very rapidly, and are strong swimmers. As the Emu is extensively hunted with dogs, or shot, on account of the damage it does to pasture land and wire fencing, as well as for the sake of its flesh, it runs the risk of extermination. At one time it was almost as abundant in the neighbourhood of Port Jackson and Botany Bay as the kangaroo and the wallaby, but it is now only seen in the interior, and is becoming scarcer every year.

The Ostrich, the largest of living birds, is now confined to Africa, Arabia and Syria, but the fact that it once had a much wider range is indicated by its fossil remains being found in India. It is distinguished from all other birds by having only two toes. The toes bear thick, stunted claws, and are padded beneath, the entire foot being exceptionally strong and stout.

The wings are larger than in the cassowary and emu, and, although useless as organs of flight, are used by the bird as sails to add to its speed when running. A full-grown Ostrich often stands eight feet high; its great length of leg and enormous stride combine to make it the fastest of running creatures. It will quickly outdistance a galloping horse, as with outspread wings it speeds across the plains, covering twenty-five feet or more at a single stride. Indeed, if it were not for its habit of running in a circle, it would be impossible to overtake and capture a running Ostrich. Unlike the emu, the Ostrich is polygamous, each cock bird having five or six mates, for whom he usually does battle at the beginning of the mating season. At other times of the year, flocks of forty or fifty birds are often seen in company, and it has been noticed by travellers that they have a curious liking for the companionship of zebras, hartebeests, and other species of antelope. In its wild state the food of the ostrich is strictly of a vegetable nature, and as an aid to digestion it swallows a quantity of grit and large stones, but in captivity this bird will eat almost anything of an animal or vegetable nature, and swallows bones, nails, coins, or any other strange thing it can pick up. Although it will drink freely when a supply of water is at hand, an Ostrich will rarely go out of its way to seek it, and is able to exist for very long periods without drinking at all.

The Rhea in South America takes the place of the ostrich in the Old World, and is often called the "American Ostrich." The Rheas agree in many ways with the ostriches; the head, neck and bill are similar, and in both families of birds there is no after-shaft to the feathers. The legs and feet are equally stout and strong, but the Rheas have three toes, instead of two, terminating in strong claws. The largest species is about two feet shorter than the ostriches, and they run with great speed, raising their wings alternately above the back, apparently to quicken their pace. Rheas are gregarious in habit, consorting together in flocks of twenty or more, and are frequently seen in company with deer or guanacos. In the breeding season the birds separate, each cock bird going off with several hens, which he jealously guards, attacking with great viciousness any other male bird which attempts to interfere with them. Although such large and striking-looking birds in their natural haunts—the treeless flats of the Argentine pampas

and the scrub-covered plains of Patagonia—Rheas are very inconspicuous, owing to the greyish-blue colouring of their plumage, which causes them to merge into the distant haze, rendering them almost invisible even at a short distance.

All the remaining birds are included in the great division **Neornilitus carinatæ**, an enormous class of birds comprising a vast number of orders, families and species, whose chief characteristic lies in the fact that, with a few exceptions, they all have a keel to the sternum. It is impossible here to do more than give a brief description of some of the more interesting and important groups of the Carinate birds, and we will first consider the aquatic birds, for amongst these we find the oldest types, and a very large proportion of all modern birds are aquatic or semi-aquatic—swimming or wading birds.

The Penguins are an extremely archaic group of birds inhabiting the Southern Ocean, for the most part passing their lives in the icy waters of the Antarctic seas. Like the *Ratitæ*, the Penguins have lost the power of flight, but the wings are modified into swimming organs, and the birds lead an aquatic existence, and are scarcely seen on land except in the breeding season. They are curious-looking creatures that appear to have no legs, as the limbs are encased in the skin of the body, and the large, flat feet are set so far back that the birds waddle along on land in an upright position in a very ridiculous manner, carrying their long, narrow flippers held out as if they were arms. When swimming, the Penguins use their wings as paddles, while the feet are used for steering. The bones of the wings are highly compressed and inflexible, so the wings cannot be closed, but they work freely from the shoulder in a rotatory manner, and the muscles that move them are remarkably strong. The name "Penguin" is said to have been derived from "pin-wing," i.e. pinioned wing. The family includes several species, of which the most important are the King Penguin, the Emperor Penguin, the Gentu Penguin, the Adélie-land Penguin, the Rock-hopper, the Yellow-crested Penguin, the Blue Penguin, the Black-footed Penguin, and the Jackass or Cape Penguin.

In their habits Penguins are usually gregarious; in the sea they swim together in "schools," and on land assemble in great numbers in their "rookeries." They are very methodical in their ways, and on leaving the water the birds always follow well

defined tracks, leading to the rookeries, marching with much solemnity one behind the other in soldierly order.

The largest species are the King Penguin (*A. pennanti*) and the Emperor Penguin (*A. forsteri*), the former being found in Kerguelen Land, the Falklands and other southern islands, and the latter in Victoria Land and on the pack-ice of the Antarctic seas. The Emperor Penguin stands nearly three and a half feet high; it is a blackish-grey bird with a white breast, and a yellow spot on each side of the head. As they are unaccustomed, from the isolation of their haunts, to being hunted and persecuted by man, these birds are remarkably fearless, and Antarctic explorers invading their territory have found themselves objects of curiosity rather than fear to the strange birds, who followed them about as if they were much astonished at their appearance. The Emperor Penguin lays but a single egg, and breeds during the intense cold and darkness of the Antarctic winter. To prevent contact with the frozen snow, the bird places its egg upon its flat, webbed feet, and crouches down upon it so that it is well covered with the feathers. In spite of this precaution many eggs do not hatch, and the mortality amongst the young chicks is very great.

The Cape Penguins range from western South America to South Africa. They either deposit their eggs in burrows, or make rough nests consisting of a pile of pebbles and rubbish, according to their locality. In Australia and New Zealand the nest is usually made of grass and leaves in a hollow in the rocks or a depression in the ground.

The Rock-hoppers are so called from their manner of hopping from one boulder to another. The name is applied to several species who have this manner of locomotion. They often form very large communities and are said to be very pugnacious and thievish towards one another. The Little Blue Penguin of New Zealand and South Australia is a much smaller bird, not more than nineteen inches in height. Its back, head and the upper side of its flippers are light blue in colour, and its under parts are gleaming white. The fossil remains of Penguins found in New Zealand show that in prehistoric times they were a much larger race of birds, some, apparently, being over six feet in height.

The Divers of the Arctic and sub-Arctic regions and the Grebes of the temperate regions are closely related, for, although

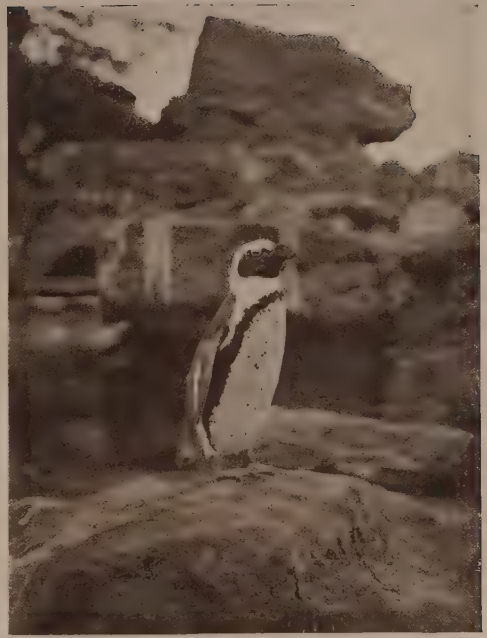
the two families differ in habits and habitat, they have in common certain peculiarities of structure. The Divers are marine birds, and unless driven inland by stress of weather are rarely seen on the quieter waters, except in the breeding season, when they ascend the rivers in pairs and nest on the moors. The Black-throated Diver and the Red-throated Diver both breed on small islands on the lakes or little pools upon the moors in Scotland. The Great Northern Diver breeds in Iceland, Greenland and in the fur countries. On land these birds appear somewhat ungainly, as they walk with difficulty owing to the legs being set very far back, but in the water they are agile and graceful, being expert swimmers and divers. In Scotland the Red-throated Diver is called the "Rain-goose," as before storms it frequently utters its loud and rather melancholy cry.

Although a few Grebes frequent the seas in certain periods of the year, they are, as a whole, fresh-water birds. The best-known British species is the Little Grebe, or Dabchick (*Podicipes fluviatilis*), that frequents the rivers and meres. It is a shy bird, and when alarmed instantly dives under water. The Great Crested Grebe (*P. cristatus*) is also seen in British waters; it frequents reed-covered pools in the summer months, but in the winter it departs to the sea.

The Albatrosses, Fulmers, Shearwaters and Petrels are grouped together under the name *Tubinares*, or tube-nosed birds, from the fact that in this order the nostrils are produced into tubes which are directed forward on the beak. They are pelagic birds with wonderful powers of flight, chiefly frequenting the Southern Hemisphere, although representatives are found in the seas in nearly all parts of the world. In size these birds vary very greatly; the Wandering Albatross, the largest species, often measures twelve feet from tip to tip of its outstretched wings—a wider spread of wing than that of any other living bird—while the Storm-Petrel, the smallest of the Tubinares, is not much larger than a swallow.

The Albatross family (*Diomedeivæ*) have their curious nasal tubes placed far apart on either side of the beak, and they are also distinguished by the extreme length and narrowness of the wings. The Wanderer (*Diomedea exulans*), the most notable of the Albatrosses, in spite of its large size, is wonderfully light, weighing no more than sixteen or seventeen pounds, and is capable

Great Auk



Cape Penguin

Pelican

Dark-bodied Pelican

Cormorant Nesting

of sustained and buoyant flight equalled by no other living bird: "Although during calm or moderate weather it sometimes rests on the surface of the water, it is almost constantly on the wing, and is equally at ease while passing over the glassy surface during the stillest calm, or flying with meteor-like swiftness before the most furious gale; and the manner in which it just tops the raging billows and sweeps between the gulfy waves has a hundred times called forth my wonder and admiration. Although a vessel running before the wind frequently sails more than two hundred miles in the twenty-four hours, and that for days together, still the Albatross has not the slightest difficulty in keeping up with the ship, but also performs circles of many miles in extent, returning again to hunt up the wake of the vessel for any substances thrown overboard."[1] When on land, or suddenly dropping down on to the surface of the water to seize some floating morsel, the Wanderer, however, loses its grace and dignity; "he raises his wings, his head goes back, and his back goes in; down drop two enormous webbed feet, straddled out to their full extent, and with a hoarse croak, between the cry of a raven and that of a sheep, he falls 'souse' into the water. Here he is at home again, breasting the waves like a cork. Presently he stretches out his neck, and with great exertion of his wings runs along the top of the water for seventy or eighty yards, until, at last, having got sufficient impetus, he tucks up his legs, and is once more fairly launched in the air."[2]

The Giant Petrel, or "Nelly," as it is sometimes called (*Ossifraga gigantea*), is but little inferior in size to the Wanderer, whom it almost, if not quite, equals in power of flight. It haunts the coasts of Kerguelen and Prince Edward Island, and other lonely spots in the southern seas, on the look-out for food. In habits it has been compared to a vulture by Professor Morley, who says that it watches the sealers at work, and no sooner is an animal killed and skinned than numbers of Giant Petrels appear, as if by magic, and descend upon the carcass, tearing it with their strong beaks, and fighting and quarrelling among themselves over the prize.

The Storm-Petrel (*Procellaria pelagica*) breeds in Scotland, Ireland and in some parts of the West of England, and ranges from Greenland to South Africa. It is a graceful little bird, sooty-

[1] J. Gould. [2] Prof. Hutton.

black in colour, with some white touches on the tail and wings. By sailors this bird is commonly called " Mother Carey's Chicken," and is looked upon as a bird of ill-omen, as it is supposed to bring bad weather. As a matter of fact, when a storm is approaching flocks of Storm-Petrels are often seen skimming over the water, feeding on the molluscs and other small marine creatures which at this time rise in quantities to the surface. From its habit of lightly skimming over the waves as if it were walking on the top of the water, the bird has gained its name " Petrel," which means " Little Peter."

The Gannets, Cormorants, Darters, Tropic Birds, Frigate-birds, and Pelicans are grouped together in the sub order **Steganopodes**—birds characterised by having all four toes connected by a web. They are all aquatic, and for the most part marine birds.

The Gannet (*Sula bassana*), or Solan Goose, is a large, heavily built bird measuring some three feet in length. On land it is rather clumsy in its movements, but its flight is easy and powerful. It feeds on fish and other forms of marine life frequenting the surface of the sea, and dives into the water after its prey from a considerable height. As it hurls itself down from aloft the Gannet keeps its wings spread until the last moment, only completely closing them as it plunges beneath the water. It is a well-known bird in Great Britain, nesting at several stations off the west coast, the largest numbers being found on the Scottish and Irish coasts. It also frequents the shores of North America and Greenland, and in winter resorts to Northern Africa and the Gulf of Mexico. Other species are found in various parts of the globe.

The Common Cormorant (*Phalacrocorax carbo*) is a well-known bird on most parts of the British coast, and is occasionally seen inland, on tidal rivers. The smaller Shag, or Green Cormorant (*P. graculus*), occurs more frequently on the western coast and in Ireland. The family contains several species, the plumage of the upper parts in all cases being black tinged with green, blue, violet, bronze or metallic hues. In the mating season many male Cormorants are adorned with a crest of white feathers, and the Common Cormorant is further distinguished by having white patches on its thighs. The neck of the Cormorant is long and the skin of the throat can be dilated to form a pouch for food. Fish forms the chief food of the majority of species, but the diet is

varied in many cases with small crustaceans, or sometimes even newts and frogs. When first hatched the young are fed by the parent birds with partially digested and regurgitated food, and as they grow older they thrust their heads into their parents' gaping bills and help themselves to the contents of the pouch. These birds are very expert in catching fish, and when engaged in this pursuit will swim for a long time with the head under water; they are voracious, and will often catch more fish than they can possibly swallow. In China and Japan Cormorants are trained to catch fish, a strap being fastened round the neck to prevent them swallowing their prey, which is taken from them by their owners. Fishing with Cormorants is also practised as a sport in various parts of Europe. On land these birds have an ungainly waddle, but their flight, though heavy, is strong and swift, and in spite of their webbed feet they are able to perch easily on rocks, posts and even in trees. They are said, too, to be able to cling to the face of a cliff, and in some cases to climb about with ease amongst dense vegetation.

The Snake-bird, or Darter (*Plotus anhinga*), is a native of tropical and sub-tropical America. It is distinguished from the cormorant by its longer body and its peculiarly long, snake-like neck, at the end of which is a small head, flat and narrow, terminating in a long, fine, tapering bill. Darters frequent inland lakes and rivers and inlets of the sea, and are fond of sunning themselves on a post, a tree stump, rock, or a tuft of stout rushes. Fish is their principal food, which the birds impale on the end of their dagger-like beaks. They swim with the body submerged, the head and neck alone being exposed, which, as the birds move through the water, sways from side to side in a graceful, snake-like manner; from this peculiarity the Darters have gained the popular name of "Snake-birds."

The Frigate-bird, or Man-of-War Bird (*Fregatus aquila*), is a handsome, powerful bird frequenting the tropic seas. It is pelagic in its habits, and is constantly on the wing, seldom being seen near land, except in the breeding season. Strong and graceful in its flight, the Frigate-bird often soars aloft until it is almost lost to sight, and from this it has gained the picturesque title of the "Son-of-the-Sun."

The Frigate-bird is slender in build, its neck is short and thick,

and its powerful bill is long and abruptly hooked at the tip. The legs are short, and feathered down to the toes, and the webs of the feet only extend a short distance up the toes. The wings are very long, and the tail is forked like a swallow's. The plumage of the male is a sooty-brown, relieved with purple and green reflections, and its throat-pouch, which is inflated in flight, is scarlet. Like other *Steganopodes*, the Frigate-bird is a clever fisher; it will pursue surface-swimming fish, and deftly seize them with its bill without ruffling the water; a large portion of its food, however, is obtained by robbing other birds, such as terns and gannets, of their lawful prey; it will descend suddenly upon them with such fury that in most cases the assaulted bird is glad to drop its fish, and make good its escape while the robber swoops down and catches the fish before it reaches the water. It is said that the Frigate-bird will even seize a recalcitrant gannet by the tail and give it a vigorous shaking if it does not quickly disgorge its prize.

The Pelicans are distinguished by their enormous bills and the extraordinary membranous pouch which fills the space between the branches of the lower jaw. They frequent tidal rivers, inland lakes and marshes in most of the warmer parts of the world.

The Auks, Guillemots, Razor-bills and Puffins are included in the family *Alcidæ*. They are all sea-birds, mainly confined to the cold northern regions. All are heavily built birds, with relatively large heads, and legs set far back, giving them an awkward walk; the wings, though short, are strong, efficient flying organs. They are not gregarious, except in the breeding season, when they flock in vast numbers to their accustomed haunts with remarkable punctuality, often, it is said, arriving to the exact day. The Little Auk (*Mergulus alle*), whose breeding ground ranges from Greenland and the Kara Sea to North Iceland, is a not infrequent winter visitor on our coasts, and occasionally migrates as far as New Jersey, the Azores and the Canaries. It is a small black-and-white bird, about seven or eight inches in length, and has a thick, short bill.

The Guillemots, Razor-bills and Puffins all breed in Great Britain. In the spring they assemble in great numbers with gulls and terns in their regular nurseries on rocky coasts. It is stated in Yarrell's "British Birds" that "about the middle of March in the South

of England, and early in April in the northern portions of our islands, the Razor-bills, Guillemots and Puffins converge to particular points, where, from the numbers that congregate, and the bustle apparent among them, confusion of interests might be expected. It will, however, be found that as a rule the Guillemots occupy one station or line of ledges on the rock, the Razor-bills another, the Puffins a third, the Kittiwakes a fourth ; whilst the most inaccessible crags seem to be left to the Herring Gulls. The Razor-bills generally select the higher and rougher ledges, and they are partial to crevices, their eggs being sometimes disposed so far in that it is no easy matter to get at them ; at other times they lay their eggs on the broader shelves along with the Guillemots, but not so closely together." Many of the small, rocky islands of the coast of Scotland and the North of England are regularly taken possession of by the sea-birds in the breeding season. Year after year they return to their accustomed haunts, driven by the mysterious call of Nature to leave for awhile their free, wandering life, and seek the shore where they may lay their eggs and bring up their young ones in safety. The rocks are sometimes white with birds, so densely packed together that a late comer often has much ado to find a place among the throng ; and the noise when they are disturbed, and rise in a whirling cloud, screaming, into the air, is simply deafening.

The Common Guillemot (*Uria troile*) is a fairly large bird about eighteen inches in length. It has a long, tapering bill, and its plumage is dusky brown above and white below. The Winged Guillemot is simply a variety of this species, distinguished by having a white ring round the eye and a white streak behind it. The Black Guillemot of the North Atlantic, a black bird with a white wing patch, is only seen in the North of Britain.

The Razor-bill and the Puffin are somewhat similar-looking birds, but are easily distinguished by their bills, that of the former being short, stout and somewhat razor-shaped—whence its name —while the latter has a large, parrot-shaped bill, and, in consequence, is often called the " Sea-Parrot." In the mating season the huge bill is encased in a gaudy-coloured sheath, which gives the male bird a most grotesque appearance. The tip is a brilliant red, and the remaining portion is adorned with bands of slaty blue, yellow and red. It is further embellished with a rosette of

yellow skin at the angle of the mouth. This remarkable sheath, in conjunction with the bird's white cheeks, black cap and throat circlet, white breast, black back, and orange-coloured legs and feet, gives the Puffin the most peculiar appearance. The sheath is shed with the annual moult, and the rosette turns from yellow to a pale reddish hue. The Tufted Puffin (*Lunda cirrhata*), which ranges from Japan to South California, is further adorned with two long tufts of straw-coloured feathers overhanging the eyes when clad in his nuptial garb, the beak red and yellow, the rosette red, while the plumage is sooty above and greyish below. In the Pacific the family is represented by the large Horned Puffin (*Fratercula corniculata*), distinguished by the long, horny processes projecting from the eyelids. These horns are present in all species of Puffin, though not in such a marked degree. Like all the Auk tribe, Puffins are expert swimmers and divers, and can swim for a considerable time beneath the water.

At one time grouped with the divers and grebes, which they resemble in the backward position of the legs, the Auks are now included in the same order as the plovers, sandpipers, sheath-bills, eand-grouse, coursers, jaçamas, stone-curlews, gulls, terns and skuas, and the pigeon tribe.

The Gulls, Skuas, Skimmers and Terns belong to the family *Laridæ*. Although differing in many ways one from another, all the members of the family agree in having the three front toes connected entirely or partially by a web, and there are certain anatomical details common to all.

The Gulls (sub-family *Larinæ*) are essentially marine birds, though some species nest inland, and ascend the rivers in the winter months. They have a very wide distribution, different species being found in almost all parts of the world. Gregarious and roving in their habits, the Gulls are equally at home on the wing or on the water. Their wings are strong, and they are capable of long sustained flight. In their natural elements they are exceedingly graceful, and on land they walk well but with a curious straddling gait.

The British species include the Herring Gull (*L. argentatus*), the Black-headed Gull (*L. ridibundus*), the Lesser Black-headed Gull (*L. fuscus*), the Greater Black-backed Gull (*L. marinus*), and the Kittiwake (*Bissa tridactyla*). The Common Gull (*L. canus*),

the Glaucous Gull (*L. glaucus*), and the Iceland Gull (*L. leucopterus*) are winter visitors.

The Herring Gull, one of the commonest species on our coast, is a handsome bird. The summer plumage is white, save for the blue-grey mantle and black primaries, the latter having white tips and "mirrors," or round white marks; in winter the head becomes streaked with brown. Young gulls are mottled brown and white, and are much less conspicuous when at rest than the adult birds. Although they are accused of stealing the eggs of other birds, Herring Gulls chiefly feed on fish, varied by refuse thrown from ships, or any small marine creature thrown up by the tide. Flocks of gulls will often follow the herring shoals, and by the noise and commotion they make warn the fishermen of the approach of the shoals. The Black-headed Gull (*L. ridibundus*) is fond of nesting on marshlands. In its summer dress the head and upper part of the neck are dark brown and the beak a deep bright red, but in the winter the bird loses its characteristic hood. In the winter flocks of Black-headed Gulls ascend the rivers, and in the spring they are often seen following the plough in company with rooks and starlings, feeding upon the grubs turned up with the soil. The Laughing Gull (*L. atricilla*) of America is a member of the same group of gulls. It is a larger bird, and is distinguished by having the outer primaries black, just tipped with white. The largest of the Hooded Gulls (*L. ichthyaëtus*) ranges from the Black Sea and the Levant to Tibet, and passes the winter in Southern Asia. The male bird is often twenty-seven inches long, and in the nesting season he wears a jet-black hood and his bill is a bright orange-red.

The Great Black-backed Gull, one of the largest species, is not common on our shores, but breeds on the Scottish coast. It is less sociable in its habits than most of its tribe, and is a very fierce and thievish bird. It will steal the eggs and young of other birds, devour rats, mice, fish, or small birds indiscriminately, and even attack and kill weakly lambs. The Lesser Black-backed Gull is a less aggressive bird, and more social in its ways. It nests in company with other sea-birds on many places round our coasts.

The Kittiwake, the smallest and prettiest of British-resident gulls, is a dainty bird, with snow-white plumage and a mantle of silver-grey. It has gained its common name from its curious

cry of "*Kitty-wake, Kitty-wa-ke!*" while its specific name, *Bissa tridactyla*, has been given to it on account of its lacking the hind toe.

The Skuas have representatives in many widely separated parts of the world. Their principal breeding-grounds are the Scottish hills and moors in the vicinity of the sea, the tundras of Siberia, the fells of Scandinavia, and the barren shores of the Arctic region. They are bold, fierce birds, addicted to robbing other birds of their food, swooping down on terns, gulls and gannets and forcing them to disgorge the fish they have caught for themselves. The Great Skua, or Bonxie, which breeds in the Highlands, Iceland, and the Faroe Islands, will attack a man if he ventures near its nesting-place, aiming, it is said, directly at his face, and from its great size and strength is a formidable bird to encounter.

The Terns are small, graceful birds, and from their forked tails and hovering flight are often called "Sea-swallows." They are all distinctly marine birds, though some species breed on inland waters. They are constantly seen on the coast flying swiftly backwards and forwards over shallow pools and streams, every now and then plunging into the water to seize the small fishes. They will also eat small crustaceans, molluscs, frogs, newts and insects; the latter they are said sometimes to catch on the wing after the manner of swallows. Some species nest in colonies on the marshes, others on level rocks, grassy flats or sandy beaches. The nest is often a simple hole in the ground, or masses of seaweed and grasses are collected to form a soft bed for the eggs. The Noddies (*Anous*) occasionally build in trees and bushes, the materials used being twigs, grass, or seaweed. Noddies chiefly inhabit tropical and sub-tropical regions and are distinguished from other Tern by having the tail graduated instead of forked. Several species of Tern are common in the British Isles.

The Skimmers, or Scissor-bills (*Rhynchops*), somewhat resemble the terns, but are distinguished from them and all other birds by the curious formation of the bill, which is long and knife-like, with the lower mandible very much longer than the upper one. They fly low over the water with a swift, gliding motion, twisting and turning with the greatest ease. When seeking food the Skimmer opens its bill wide, and ploughs through the water or mud with the long lower half, and in this way it catches small fishes and

crustaceans, cleverly scooping them up with its peculiar bill: There are three species of Skimmer, the Black Skimmer (*Rhynchops nigra*) of America being the most familiar.

The Plovers and a host of wading birds are included in the sub-order *Limicolæ*. They are very long-legged birds, and many have also exceedingly long bills, varying in shape in different species. In the Snipe the bill is straight and tapering; in the Oyster-catcher, wedge-shaped; in the Avocet the bill curves upwards; in the Ibis it is curved down; the Wrybill, as its name signifies, has a bill twisted to one side; and the Curlew has an arched bill, somewhat like a scimitar in shape. In some species the bill is hard and horny throughout; in others, although the tip is hard, the bill becomes fairly flexible towards the base, while certain species have a comparatively soft bill furnished slightly with nerves. The wings in this group of birds are usually long and pointed and have often a bi-lobed appearance, due to the inner secondaries and outer primaries being equal. The tail is short, and the feet may be partially webbed, but the majority of species have the anterior toes free.

In their habits the wading birds are more or less migratory, and in the winter time often assemble together in flocks; but there is considerable diversity in the custom of different groups: They have, as a rule, a strong wheeling flight, can walk and run well on land, and most of them are good swimmers, although, except on emergency, they seldom take to the water. On almost every coast some of these waders may be seen paddling about on their long legs in shallow waters—on the margins of inland streams and rivers, at the river mouths, in rock pools and on flat sandy or muddy shores when the tide is low—busily feeding on the crustaceans, molluscs, worms, etc., which they obtain by plunging their long bills into the soft sand and mud.

Most of these birds have a distinct summer and winter dress, the plumage in the nesting season in many cases being very bright, while in the winter more sombre tints are the rule.

The Plovers, of which there are numerous species found in every quarter of the globe, as a rule frequent low-lying, moist situations—marsh lands, moors, and the sea-shore—but some nest on grassy commons and others in the breeding season resort to bare mountain tops. The Grey Plover (*Squatarola helvetica*), the Ringed

Plover (*Ægialitis hiaticola*), the Kentish Plover (*Æ. cantiana*) frequent coasts where there are wide expanses of sand and shingle, and their eggs may be found in a hollow on the open ground or amongst the shifty sand-dunes. The Golden Plover (*Charadrius pluvialis*) is a bird of the marshes, and so also is the Lapwing, or Peewit (*Vanellus cristatus*), but the latter often breeds on cultivated land, and its curious cry of "*pee-e-wit, pee-e-wit*" and its wheeling flight are familiar to most country-dwellers. Both birds take their share of the incubation, and, if disturbed on the nest, will circle round the intruder's head and try to lead him away from the eggs or young.

The Pigeon tribe (sub-order *Columbæ*) is divided into three families: the first, *Didida*, contains the extinct Dodo and Solitaire; the second, *Columbidæ*, all existing Pigeons, with the exception of the Tooth-billed Pigeon of Samoa, which is placed in a third family, *Didunculidæ*.

The Pigeons are all compactly built birds; the bill, which may be stout or slender, curves downwards at the tip, which is swollen and hardened, and the base is covered with a soft skin containing the nostrils. The four toes are on the same level, and many domestic pigeons have the legs and feet feathered in a greater or lesser degree. With the exception of the Ground Pigeons, which have short, rounded wings, the species have long, pointed wings, and a strong flight; many, indeed, traverse enormous distances at an extraordinarily rapid rate. Many Pigeons are exceedingly beautiful birds and very interesting in their ways. They usually frequent wooded districts, and some species are to be found in nearly all parts of the world. The nest is a rough platform composed of a number of twigs and sticks and the male and female, who pair for life, share the duties of incubation, and feed the young birds, which are at first helpless and naked, with a milky fluid secreted by certain glands which develop in the parents' crop during the breeding season. This fluid, combined with the partially digested food in the crop, is what is sometimes spoken of as "pigeon's milk." Wood Pigeons feed on grain, acorns, beech-mast, and the young shoots of plants, and are also fond of turnips; the Fruit Pigeons, on various fruits plucked from the trees; Ground Pigeons, chiefly on grass seeds; while certain species eat insects snails and worms, and the Nutmeg Pigeon, one of the Fruit Pigeons,

is said to live chiefly on nutmeg and mace. Unlike the majority of birds, Pigeons drink considerable quantities of water, taking long draughts with the bill submerged to the base.

The Rock Dove (*C. livia*), the Stock Dove (*C. œnas*), and the Wood Pigeon (*C. palumbus*) are British species, the first breeding on the northern coasts of Scotland and Ireland in caves and holes in rocks; the second on rocky ledges or in rabbit-burrows in the eastern and southern counties of England; and the third is common in most parts of Great Britain. The Painted Pigeons are small, brilliantly coloured birds, ranging from Australia to the Malay Peninsula. The Passenger Pigeons of America are distinguished by their remarkable powers of flight; their wings are exceedingly long and narrow, exceeding the tail in length. Many species are adorned with remarkable crests, ruffs, or other striking peculiarities too numerous to mention here, and the Fantails, Tumblers, Pouter Pigeons, and Carrier Pigeons are familiar to everyone.

The Tooth-billed Pigeon is a rare and remarkable bird inhabiting the Island of Samoa. It is the only representative of its family, and is peculiarly interesting on account of its kinship to the extinct dodo. This pigeon is a large bird with glossy black plumage, having a greenish tint on the head, chest and mantle, chestnut-coloured wing-coverts, and tail and under parts brown. The feet are red, and the bill, which is hooked and serrated, is orange Formerly this bird nested on the ground, and at one time was in danger of extinction, but it gradually acquired the habit of building in trees, and since then has increased in numbers.

CHAPTER XXI

THE BIRDS (Continued)

The Rails, Coots, Moorhens, Bustards, Sun-bitterns, and Cranes are grouped together by many authorities in the order **Gruiformes.** Although the various tribes differ considerably one from another, they all agree in having no true crop, and there are several other anatomical points of resemblance. Many are waders, others water birds, while some—the trumpeters, bustards, and land-rails—are inland birds. The Rails are a large family of somewhat similar form, species of which are found in almost all parts of the world. The Land-rail or Corncrake (*Crex pratensis*) is a summer visitor in the British Isles, frequenting long grass and cultivated land, where from its shy habits it is seldom seen, though in the evening its grating cry of "*crek-crek*" is often heard. The Coot and the Moorhen are both members of the Rail family. They are both familiar British birds, and often confused one with another; they may, however, be easily distinguished by their colouring—the Coot is dark grey on the back, and has a white shield on the front of its head, and the Moorhen is olive-green above, and has a red frontal shield.

The Cranes are amongst the largest of wading birds. They frequent marshy districts and open plains, and are most abundant in North-East Asia, though species are to be found in several other parts of the globe. Except in the breeding season Cranes are gregarious, and are often seen in flocks in corn and rice fields, in forest clearings, or open country; in the winter months the northern species migrate southwards. They are most amusing in their ways—striding about in a dignified manner, or in the springtime leaping with outstretched wings into the air, bowing to the ground, and performing the most remarkable antics and dances. Amongst many varieties are the Great Wattled Crane (*Grus carunculata*) of South Africa, distinguished by having two

feathered wattles depending from the chin; the Demoiselle Crane of Northern Africa, Spain, and the South of Russia, a small and graceful bird with delicate grey plumage, black head and breast, and tufts of white feathers extending backwards from the eye; and the Crowned or Crested Crane of Africa, which is adorned with handsome fan-shaped crests of stiff twisted feathers on the top of the head.

At one time the Cranes were classed with the storks and herons, but although resembling them in outward appearance they are not nearly related. The Herons and Storks are allied to the pelicans, frigate-birds, cormorants, etc. Herons, although by no means common birds, are familiar to most people; they are shy and solitary in their habits, though they often breed in colonies. They may often be seen standing in the shallow water on the margins of rivers or inland streams and lakes, fishing for their food, or flying to and from their favourite feeding grounds with great flapping of wings, and the head drawn back on to the shoulders. Night Herons usually frequent wooded districts in the vicinity of swamps, and although they have a world-wide distribution, are rarely seen on account of their nocturnal habits. Bitterns live in marshlands, and were at one time common in England, but since the draining of the swamps and reed beds they have become but rare visitors.

The Egrets—the Great White Heron of the Old World, the Little Egret of southern and south-eastern Europe, and the Australian Plumed Egret—belong to the Heron family. In the breeding season these birds display the beautiful plumes known as "ospreys," and for the sake of them they are murdered in thousands, and the young nestlings, bereft of their parents, are left to die of starvation. I cannot but believe that if this terrible fact were more widely known, no woman would be induced to buy or wear the delicate plumes so ruthlessly torn from the heads of these poor birds; as it is, unless some steps are taken to stop the wholesale killing of the Egrets, before very long they will become extinct.

The Storks range over most parts of Europe, and extend through Turkey and Persia to India and Central Asia, and in the winter visit Africa in great numbers. The White Stork (*Ciconia alba*) is fond of building near human habitations, and often chooses the roof of a house for the site of its nest, which is composed of a great

mass of sticks. It will return year after year to the same spot with great regularity, and its arrival is eagerly looked for by people on whose house-roof it takes up its abode in the spring. Adjutant Storks are said to make a loud grunting sound, but the majority of the Stork family are voiceless, owing to the lack of voice-muscles, and are only able to express themselves by clattering their beaks.

The Sacred Ibis (*Ibis æthiopica*), portrayed so often in ancient Egyptian hieroglyphs, is closely allied to the storks. The *Ibididæ* is divided into two sub-families, the Ibises (*Ibidinæ*) and the Spoonbills (*Plataleinæ*). The Ibises have a long, soft bill, hard at the tip, and curved downwards; the Spoonbills, as their name implies, have a peculiar wide, spoon-shaped bill, which is said to be polished and actually used as a spoon by the natives of certain parts of Africa. The birds frequent pools and swamps, and wade in the shallow water in search of crustacean and other water creatures, to which they are very partial. The Spoonbill (*Platalea leucorodia*) once bred regularly in Norfolk and Suffolk, but is now only an occasional visitor to British shores. It frequents many parts of Europe and Asia and Africa. Other species inhabit Australia, New Zealand, and the Ethiopian regions. The Flamingos occupy a position between the Storks and the Geese.

The Swans, Geese, and Ducks are grouped together into one family—the *Anatidæ*. They agree in having large, ovate bodies, well-developed necks (which attain the greatest length in the Swans), short legs and webbed feet, but their most distinctive characteristic is the presence on the edges of the upper mandibles of a series of highly-developed upright plates or *lamellæ* which act as a sieve to drain the water from the food taken in the beak, and are also useful to nip off herbage and grip fish.

In their habits most members of the family are very similar. They frequent rivers, streams, pools and seas, for the most part in the northern regions, being most numerous on the shores in the winter time, and are more or less gregarious and migratory. There are comparatively few species of Swan. The Mute Swan (*Cygnus olor*) is common on British rivers, particularly on the Thames, where, being a "protected" bird, it fortunately escapes extermination. The Whistling Swan (*C. musicus*) and Bewick's Swan (*C. bewicki*) are winter visitors. The handsome Black Swan (*Chenopsis atrata*) is a native of Australia; it is sometimes seen on ornamental

Spoonbill

Black-necked Swan

King Vulture

Griffon Vulture

waters, as is also the Black-necked Swan (*C. melanocory*) of South Brazil, Chili and Patagonia.

With the exception of our domesticated species most Geese and Ducks are winter visitors to Britain, though some stay to breed in its waters. The Bean Goose comes from the tundras of north-east Russia, the Brent Goose from the far north, and the Bernacle Goose, numerous on the west coasts during the cold season, is a migrant from Greenland and the northern parts of Europe.

Amongst the Ducks frequenting British shores are the Mallard or Wild Duck (*Anas boscas*), the Shoveller (*Spatula clypeata*), the Pochard (*Nyroca ferina*), the Scoter (*Oedemia nigra*), and the Red-breasted Merganser (*Mergina serrator*). The Eider Duck (*Somateria mollissima*), noted for the down the mother bird plucks from her breast to cover her eggs in the breeding season, inhabits the rocky coasts of Norway, Iceland, and the Faroe Islands, where the collecting of down is an important occupation. Occasionally the bird breeds on the northern coast of Scotland, but it is more generally a winter visitor.

The **diurnal birds of prey**, from their great size and strength and dominating ways, were placed by the older naturalists at the head of all birds; but from this proud position they have been deposed by later authorities, their place being taken by the *Passeres* or perching birds, the most highly developed order of the class Aves.

In the bird kingdom the vultures, eagles, and hawks take the place of the lions, tigers, hyenas, and jackals of the mammalian world; all are of carnivorous habits, preying upon their own kind, reptiles, and the smaller mammals. Some eagles will attack large animals, such as deer and ponies, and vultures are chiefly carrion feeders.

The birds of prey are grouped together in the order **Falconiformes**, and the order is divided into two sub-orders, the first containing the New World vultures (*Cathartæ*), and the second the Old World vultures, eagles, hawks, falcons, ospreys, and the secretary bird (*Accipitres*).

The New World Vultures range through tropical and temperate America. They are mostly large birds, some of immense size, with great, strong wings, and powerful, hooked though blunt bills;

the feet are clumsy, and the claws straight and blunt and not fitted for grasping. The head and long neck are usually bare, though sometimes covered with short stubbly down, the naked skin being often brightly coloured; the eyes are prominent, and the birds have remarkably keen sight:

In finding the carrion upon which they feed, Vultures are said to be guided by sight and not by smell. No sooner does one swoop down upon a carcass than his action is seen and understood by others far and near, and before long a greedy crowd will gather on the scene to quarrel and fight over the find until every morsel is consumed. Then, gorged with food, they sit about with drooping wing in a stupid and half-dazed condition, and at such times are easily captured.

The Condor of the Peruvian and Chilian Andes is one of the largest of flying birds. It is about four feet in length, and has a wing expanse of nine or ten feet. It not only feeds on carrion, but will attack lambs, goats, deer, and old, feeble horses. The King Vulture is very like the condor, but is distinguished by a small fleshy crest on the base of the beak and the bright colours of the skin of the head and neck; the dominating tone is orange-red, and near the ears are patches of blue, while the bill is orange and black. It is found chiefly near the coast, haunting woods in the neighbourhood of marshes or rivers.

The Old World Vultures are very similar in habits and appearance to the condor tribe, but from certain anatomical differences they are placed in a separate family. They vary greatly in size, the Egyptian Vulture (*Neophron percnopterus*) being about the size of a crow, while the Great Eared Vulture (*Otogyps auricularis*) of Africa almost equals the condor in size. The Griffon Vulture (*Gyps fulvus*), a native of Spain, India, and Northern Africa, occasionally visits Germany and Poland, and is said once to have appeared in England. It may be seen motionless on the rocks in the daytime basking in the warmth of the sun, or circling overhead with a strong easy flight, occasionally soaring aloft until it is but a mere speck in the sky.

The Egyptian Vulture, called from its frequent appearance in Egyptian hieroglyphs "Pharaoh's Hen," and in South Africa, where it is a winter visitor, the "White Crow," is protected by law in Egypt, and acts as a scavenger in the streets, walking fear-

lessly about with sedate strides, picking up the refuse thrown into the gutters.

The family *Falconidæ* includes the eagles, kites, buzzards, hawks, falcons, and the bearded vultures, which have some of the characteristics of both the vultures and the eagles. While the vultures are stupid and cowardly, the eagle tribe is noted for the boldness and alertness of most of its members. They wage war upon all weaker creatures, and some eagles even attack animals larger than themselves. They vary in size from the Great Bearded Vulture (*Gypaëtus barbatus*) to the tiny Finch-Falcon (*Microhierax fringillarius*), and differ considerably in general appearance, but their ways are alike in many respects, and certain points of structure are common to all. The wings are always powerful, but may be long or short, pointed or rounded; the beak is short and stout and hook-shaped; the talons curved and sharp, fitted for grasping and tearing.

The Eagles chiefly frequent mountainous districts, rock-girt shores, or high open moorlands, where they live in pairs or in solitary state. The female is in most cases the larger of the birds, and is fiercer than the male, particularly when guarding her young. On the ground Eagles progress by a series of hops, their wings the while being half expanded; their flight is graceful and majestic, their powers of endurance being exceeded only by those of the albatrosses, cranes, storks, and some of the larger gulls.

The Golden Eagle (*Aquila chrysætus*) is typical of its kind, and is one of the largest of the European birds of prey. At one time fairly frequent in England, it is now only an occasional visitor, and when it appears it is usually promptly shot—surely a curious method of encouraging rare birds to visit the country. Abroad it has a wide distribution, occurring in most parts of Europe, Asia, North America to Mexico, and in North Africa.

Amongst the British hawks are the Merlin (*Falco æsalon*), the Kestrel (*Cerchneis tinnunculus*) and the Sparrow Hawk (*Accipiter nisus*); the two latter are fairly common throughout the British Isles, but the Merlin is chiefly confined to the north.

The **Gallinæ**, or **Galliformes**, is a large order comprising all the game birds and the domestic fowls, and contains a vast number of species and varieties. The various families of the group differ considerably in many ways, but mostly agree in being of robust

build and having strong legs and toes adapted for swimming. They are principally grain feeders, but the young are often supplied with insect food, and herbage of all kinds is frequently devoured. The crop is very large, and in this the food is first macerated, afterwards being ground up in the gizzard with the help of stones and grit swallowed by the birds. Pheasants, partridges, quails, grouse, ptarmigan, turkeys, peafowl, guinea-fowl, the mound-building megapodes, and the crested curassow, are a few members of this group, and amongst the foreign species are many beautiful and remarkable birds of which space forbids description. We must, however, give passing attention to the Hoatzin or Ama, a native of the Amazon Valley, a remarkable bird, included by some naturalists in the Gallinæ, and by others placed in a separate order by itself. The sternum is unlike that of any other bird, and the crop is extraordinarily large; but the chief interest centres in the nestlings, which, when hatched in a rough nest made of sticks, in a bush or tree on the margin of a stream, have well-developed claws on the thumb and index finger of the wings. The little creatures, which are at first naked, almost at once begin to climb about the boughs of the trees, using not only the feet and beak—parrot-fashion—but the claws of the wings as well, so at this state of their lives they are actually quadrupeds, and approach more nearly the archæopteryx and the reptilian birds than any other living species. As the young birds develop the wing claws are shed, and the wings assume the ordinary avian form.

The **Psittaci**, or Parrots, are a very distinct group of birds, the most notable characteristics being the large hooked bill, which has the upper mandible hinged and overhanging the lower one; and the formation of the foot, which is termed "zygodactylous"—that is to say, the first and fourth toe are permanently turned backwards. The Parrot tribe includes the parrots, cockatoos, macaws, parrakeets, and lories or brush-tongued parrots. In all there are about five hundred species, varying considerably in size, but usually distinguished by their more or less gaudy colouring. The Macaws are, perhaps, the most conspicuous members of the group, their plumage in some cases being absolutely dazzling to the eye; the Red and Blue Macaw (*Ara macæ*), with its vermilion-red, blue and yellow plumage, and the Blue and Yellow Macaw (*A. ararauna*), in its feathery garb of bright blue

and yellow, are two typical examples of these brilliant birds. Many of the Parrakeets are hardly less gorgeous than the long-tailed Macaws, and the Cockatoos, though not so vivid in hue, are distinguished by the handsome crest of feathers they bear upon their heads.

In captivity the Parrots display considerable affection and intelligence, and their amusing ways and power of mimicking the human voice and reproducing almost any sounds they hear make them exceedingly popular as cage birds. The African Grey Parrot (*P. erithacus*) is generally considered the best talker, but several other species are almost, if not quite, as clever in this respect.

Parrots are found in tropical and sub-tropical regions, their head-quarters being in Australia and the Malay countries. In their habits they are, for the most part, arboreal; in woods and forests they climb about the trees, swinging with the greatest ease from branch to branch by the aid of strong claws and stout, hooked bills. They are, too, the only birds that hold their food in their claws when feeding. In writing of the Parrots Dr. A. R. Wallace says: "They usually feed in flocks; they are noisy, and so attract attention; they love gardens, orchards and open, sunny places; they wander about far in search of food, and towards sunset return homewards in noisy flocks or in constant pairs. Their forms and motions are often beautiful and attractive. The immense long tails of the macaws, and the more slender tails of the parraquets, the fine crests of the cockatoos, and the swift flight of many of the smaller species, and the graceful motions of the little love-birds and allied forms, together with their affectionate manners, aptitude for domestication, and powers of mimicry, combine to render them at once the most attractive of all the specially tropical forms of bird life."

Parrots are essentially vegetable feeders; herbage, fruits, flowers, seeds, and nuts are their natural food; but one species at least, the Kea, or Mountain Nestor, one of the brush-tongued Parrots, has departed from the customs of the family, and has developed a taste for fresh meat. This bird lives in the southern islands of New Zealand, and from pecking at sheepskins hung up outside country stations it proceeded to attack living sheep, and occasionally even horses, alighting on the backs and tearing the

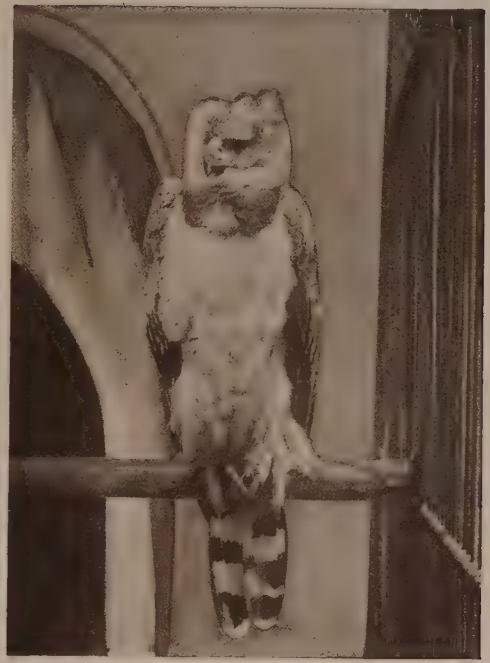
skin of the defenceless animals, and digging holes in the flesh to reach, it is said, the kidney-fat. It has, indeed, become such a terrible pest to sheep-breeders that a price has been set upon its head by the Government, and the Kea will in all probability before long be exterminated.

The Cuckoos and Plaintain-eaters are grouped by many authorities with the parrot tribe in the order **Cuculiformes,** on account of their zygodactylous feet; by others they are placed by themselves in the order **Cuculi**; others again consider that their nearest allies are the woodpeckers, kingfishers, bee-eaters, etc., from various peculiarities in their structure.

The Cuckoo (*Cuculus canorus*) is one of the birds which is more often heard than seen; nearly everyone is familiar with its monotonous note, but the bird itself is not so commonly known. In appearance it is distinctly hawk-like, which probably accounts for it being often mobbed by small birds; the back and throat are greyish brown, the breast is barred with white and dark grey, and the dusky wings and tail show a few white markings. The Cuckoo's note is heard on our shores early in April, and it repeats its monotonous cry with much persistence and energy until June, by which time it has become very hoarse, and its first note is sounded twice. In July the bird wings its way to its winter quarters in South Africa, Ceylon, or the Celebes.

The Cuckoo is chiefly interesting from its strange habit of depositing its eggs in the nests of other birds and leaving its young to be brought up by foster-parents. How the egg actually got into the nest was for a long time a matter of controversy, but it is now known that the Cuckoo lays her egg on the ground, picks it up with her bill, and so carries it to, and places it in, the nest of the bird she has chosen as its guardian. The nests most frequently selected by the Cuckoo are the hedge-sparrow's, robin's, meadow-pipit's, pied wagtail's, and reed warbler's. The birds never appear to object to the presence of the Cuckoo's egg in the nest, and when it hatches treat the intruder in every way as if it were their own offspring; nor, so far as we know, do they notice the mysterious disappearance of the rightful occupants of the nest, which are tipped over the edge by the young Cuckoo when it is some thirty hours old. When first hatched the bird has a curious depression in the middle of its broad, naked back, and into this hollow it

Golden Eagle



Harpy Eagle

Australian Fawn-breasted Kingfisher

The Great Hornbill

contrives to manœuvre the nestlings one by one, by pushing itself underneath them; then with some struggling it raises its burden to the top of the nest and tips it out.

The parasitic habit is not peculiar to all the Cuckoo tribe. Some species build nests and bring up their young in the usual bird way.

The Plantain-eaters, or Turacos (Fam. *Musophagidæ*) are striking-looking birds inhabiting the Ethiopian regions, but are not found in Madagascar. They have many characters in common with the cuckoos, but are never parasitic in their breeding habits. They are shy birds, often hiding in holes in trees, and their voice is most unmusical and is said to be a combination of a harsh scream and a catlike mew.

A large number of arboreal birds belonging to different families having comparatively short legs, which commonly nest in holes and have blind and helpless young, are grouped together in one order—the **Coraciiformes**—by some ornithologists, while others separate them into two or three orders. Amongst these birds are such varied forms as the rollers, kingfishers, bee-eaters, hornbills, toucans, hoopoes, owls, nightjars, humming-birds, swifts, trojons, barbets, woodpeckers, and wrynecks, birds which differ in a marked degree in size, form, colouring and general habits, but which have certain characteristics that link the different families one to another.

The Rollers are Old World birds, in shape somewhat resembling crows, but clothed with brilliant plumage in which the colours blue and green predominate. They inhabit wooded districts, and have gained their name from their curious rolling flight. They are strong on the wing, and twist and turn with great rapidity, and continually turn complete somersaults in the air.

The Kingfishers (*Alcedinidæ*) are remarkable for their brilliant colouring, curious truncated appearance owing to the disproportionately large head, abbreviated tail, and long, dagger-shaped bill. There are in all some hundred and fifty species distributed over nearly the whole of the globe, which vary considerably in their habits and in the colour of their plumage. The favourite haunts of the Water-Kingfishers are quiet inland streams shaded by overhanging trees. They will hawk backwards and forwards continuously over the same ground, flying low over

the water, or sit motionless on a projecting bough or stone watching for prey. Then with a sudden plunge they dive in after a fish, and bringing it back to their perch, usually give it two or three smart blows on the bough before swallowing it with a gulp. Insects and small crustaceans also enter into their diet, and this is more particularly the case in certain species that seek the seashore in the winter months. The Wood-Kingfishers frequent woods and forests, and are not particular about being near water, their food consisting of insects caught on the wing, caterpillars, molluscs, worms, and reptiles; some of the larger species will even eat small mammals and birds, after bruising them in the manner peculiar to their family before swallowing them whole.

The most usual colouring is a combination of green, blue, and chestnut, but a few of the large crested species are black and white, others are almost entirely red, some are almost wholly white with touches of bright blue or red, and some have orange and beautiful lilac tints.

The "Laughing Jackass" (*Dacelo gigas*) of Australia, distinguished by the extraordinary loud laughing sound to which it gives utterance, is one of the largest of the Kingfisher tribe, and measures nearly a foot in length. It is more sombre in hue than many of its allies, being chiefly brown, relieved with a white stripe on each side of the head and some red in the tail. The Fawn-breasted Kingfisher, another Australian species, is a smaller bird somewhat similar in colouring. The British native Kingfisher (*Alcedo ispida*) is one of the most beautiful members of the family, its plumage of bright blue relieved with blue-green, white, and orange-red rivalling that of many of the tropic birds in brilliancy. It is the most gaily coloured of all British birds, and may be seen—a flash of glittering blue—darting over the water close by the banks of many an English stream. In many districts, unfortunately, this beautiful bird is much less frequent than it used to be, while in some spots it has altogether disappeared, owing chiefly to the thoughtlessness of collectors and the extraordinary propensity shown by so many sportsmen for shooting every rare and beautiful bird on sight. As the Kingfisher is now a "protected" bird it is to be hoped it may escape the fate of extermination that has overtaken so many beautiful and interesting birds in Britain.

The Owls (*Strigidæ*) are grouped near the diurnal birds of prey

on account of certain similarities of habit, but ornithologists now agree in raising them to a higher position among the birds, considering that they are more closely akin to the nightjars and their allies. By some authorities they are classed as a sub-order—**Striges**—in the order *Coraciiformes*; others consider that *Striges* constitutes an order by itself.

The general appearance of an Owl is familiar to most people; the great round eyes surrounded by a disc of stiff feathers give the bird a peculiar air of solemnity, and in times not so very remote from the present day it was generally regarded with superstitious dread as a bird of ill-omen. Its large eyes are extremely sensitive to strong light. Owls are usually nocturnal in their habits, and their silent, stealthy flight, and weird hoots and cries, as they hunt for prey at dusk, have no doubt been responsible for their being looked upon as birds of mystery.

Owls are almost universal in their distribution, and frequent the most varied descriptions of country. Some species live in wooded districts, others in rocky ravines; on the sandy plains of both North and South America the quaint little Burrowing Owl (*Speotyto cunicularia*) lives in its underground burrow; on the cold barren lands and fjelds of the Arctic regions the Snowy Owl (*Nyctea scandiaca*) makes its nest. Holes in trees are chosen by many species in which to deposit their eggs, others take possession of deserted rabbit holes or squirrels' dreys; the Tawny Owl and the Barn Owl often make their home in old buildings and ruins, the later especially being fond of taking up its abode in belfries and old church towers.

All Owls are carnivorous, their food consisting of insects, particularly beetles; small mammals such as mice and rats; and occasionally small birds, reptiles and bats; worms, slugs and snails are also eaten sometimes; and although Owls are accused of stealing young pheasants, grouse, etc., they really are useful in destroying quantities of rats which do so much harm on game preserves, and their wholesale destruction is very short-sighted policy.

Owls have usually exceedingly long talons, sharp and curved, and the fourth toe can be turned backwards or forwards at will. When perching an Owl generally clasps its support parrot fashion, with two toes turned backwards and two forwards; but sometimes the fourth toe is turned forwards, and this is always the case when the Owl is on the ground.

The Barn Owl, or Screech Owl (*Strix flammea*), the Brown Owl (*Syrnium aluco*) and the Long-eared Owl (*Asio otus*) are the commonest British residents. The Eagle Owl (*Rubo ignavus*) and the Little Owl (*Carine noctua*) are visitors to England, and the latter has been known occasionally to breed in the southern counties.

The Nightjars, or Goat-suckers as they are sometimes called, are decidedly owl-like in appearance. They are found in most parts of the world, and their strange, jarring note is heard on open common lands and moorlands in very many parts of Britain. Nightjars are birds of the twilight; by day they rest concealed under bushes, in hollow tree-stumps or on low boughs of trees, and they are peculiar in resting lengthwise on a branch instead of across in the ordinary bird manner. The eggs are laid on the bare ground, often just under the shelter of a gorse bush or a clump of bracken, but sometimes even this protection is lacking; but as the parent bird sits very closely on the ground her colour blends so well with the soil that she is practically invisible. When sitting the Nightjar closes her eyes so that their brightness may not betray her, and she will almost allow herself to be trodden on before she will rise from the ground. The male birds in some cases take part in the incubation and sit quite as still as their mates.

These birds have an enormously wide gape, and the short, broad beak is commonly fringed with stiff bristles; the skull is much flattened and the eyes are large and bright.

The Swifts at one time were grouped with the swallow tribe, but apart from a general external resemblance, and the habit of hawking insects on the wing, the two families have but little in common and are not closely allied. Swifts are really more nearly related to the humming-birds, for, although the dark Swifts and the brilliant jewel-like humming-birds are outwardly so unlike each other, their kinship is shown in several points of structure.

Swifts are essentially children of the air. Except at night they spend almost all their time on the wing, wheeling and circling at great heights, uttering the while their shrill, piercing cry, or skimming rapidly over the ground in pursuit of insect prey. The peculiar formation of the foot makes perching a difficulty, all four toes being directed forwards, but Swifts are able to cling with ease to perpendicular surfaces, and it is said they can even climb up a rough wall or cliff. Swifts inhabit both hemispheres.

and are British visitors. One of the latest migrants to arrive is *Cypselus apus*, a fairly large bird, measuring some seven inches in length, sooty black in colour, with a white chin, very long pointed wings and a forked tail.

The Humming-birds are peculiar to the New World. They are at once the smallest and most beautiful of the class Aves. Some of the smallest species scarcely exceed a big bumble-bee in size, and the wonderful prismatic hues of the plumage of the tiny creatures as they flit about in the sunshine defy description. They dart through the air with the swiftness of an arrow, and hover over the flowers with rapidly vibrating wings, making with them the humming or buzzing sound that has given the birds their common name. These birds are further distinguished by their extremely long, slender bills—which, however, vary considerably in different species—and the curious long, extensile tongue, which consists of a slender double tube separating into two branches which are furnished at the tip with a membranous fringe. The sternum of both swifts and humming-birds is enormously developed; it is remarkably long in the keel, very deep, and the wing muscles attached to it are particularly powerful, giving to both species of birds their almost untiring powers of flight.

The last Coraciiforme birds we have room to notice here are the familiar Woodpeckers (*Picidæ*) and Wrynecks (*Ianginæ*), which are interesting, as in many points of structure they resemble the Passerine birds and so form a connecting link between the two orders. Woodpeckers are distinguished by their large heads and necks (the latter being provided with exceedingly powerful muscles), the strong, wedge-shaped bill, and the stiff and spiny feathers of the tail.

With a few exceptions Woodpeckers are shy, solitary birds, frequenting wooded districts, where in the springtime their peculiar ringing laugh and the loud drumming sound caused by the hammering of the bill on the bark of the trees are commonly heard. Their boring operations are for the most part confined to decaying trees or unsound limbs, with the object of reaching the insects concealed under the bark; and in this way, by destroying so many insect pests, the Woodpecker is really a very useful bird. The holes made for the reception of the eggs are of larger dimensions than those bored while it is seeking food, and for these sound wood is

often selected. A neat circular hole is drilled in the wood, and the shaft, at first horizontal, soon turns downwards, descending to the depth of about a foot. As the birds (both parents help in the excavation) proceed with their boring operations they gradually enlarge the shaft so that when finished it has somewhat the form of a long-necked bottle.

When searching for insects in the bark of a tree the Woodpecker usually begins at the foot and ascends in spiral fashion, eagerly examining every crack as it goes. It clings to the bark with its stout hooked claws, and further supports itself with its stiff tail feathers, while the head swings backwards and forwards with marvellous rapidity on the strong, muscular neck, and the hard, wedge-shaped bill strikes the tree with hammer-like regularity. The Green Woodpecker (*Picus viridis*), the Great Spotted Woodpecker (*Dendrocopus major*) and the Lesser Spotted Woodpecker (*D. minor*) are the British representatives of the family.

The Wrynecks differ from woodpeckers in having soft tails without stiff feathers. They nest in holes in trees, taking advantage of those already formed instead of carving them out for themselves like their more industrious allies. From its curious habit of twisting the head almost completely round, as it sits at the mouth of its hole or on a branch near by, the bird has gained its popular name—"Wryneck"; while from the hissing sound it makes when disturbed in the nest it is sometimes called the "Snake-bird." It is also locally known as the "Cuckoo's Mate" or "Cuckoo's Messenger," apparently because it usually arrives on our shores a few days in advance of the cuckoo.

The **Passeres,** or Perching Birds, are the most highly organised order of their class. In numbers they exceed the birds of any other order; some five thousand five hundred species have been named—more than half the birds known. The majority are of small size, the foot is essentially adapted for perching, and the voices are more perfect than in any other order of birds. All the true song-birds are included in this order—though all perching birds are not gifted with melodious voices—and the Passeres are classified as the *Acromyodi*, or singing birds, and the *Mesomyodi*, or songless birds, but the division is based upon the structure of the lower larynx, or *syrinx*, rather than upon the quality of the birds' voices.

A description of less than half of the Passerine birds would more than fill a volume the size of this work, and it is impossible to do more than notice briefly a few among the many interesting families belonging to the order. But for bird-lovers there are a host of books to be had, written by noted authorities on the subject.

The Thrush tribe (*Turdidæ*) is a typical group of perching birds, and representatives of the family are to be found in almost all parts of the world. It includes the familiar Thrushes and their allies, the *Turdinæ ;* the Warblers, *Sylviinæ ;* and the Mocking-birds, *Mimina ;* though by some authorities each of these divisions are treated as separate families. To the Turdinæ belong some of our most accomplished singing birds—the Song Thrush, Missel Thrush, Blackbird, Nightingale and Robin—while the Redstart and the Redwing have sweet though not powerful voices. They are typically woodland birds, frequenting almost all parts of the country, invading even the garden on the outskirts of the towns. The Nightingale, the most noted of songsters, is chiefly confined to the south-eastern parts of England, and is partial to cultivated areas such as parks and old gardens, as well as the outskirts of woods. It arrives in April; its wonderful song is heard throughout the month of May should the weather be warm, and ceases early in June. Contrary to the general idea the Nightingale's song is not confined to the hours of night; the bird sings equally well in the daytime, but, owing to the joyful chorus kept up by other singing birds during those hours in the springtime of the year, its voice is not so noticeable. The nest made by the *Turdinæ* is cup-shaped, and the young birds are usually distinguished by having spotted breasts. The Whinchat, Stonechat, Wheatear, and Hedge Sparrow also belong to this division. Many species are migratory, and the food consists chiefly of insects, worms and, in the case of the Thrush, of snails, which they often take to some favourite stone to crack the shells.

The Warblers are distinguished from the thrushes by moulting twice in the year (their allies only shedding their feathers at the end of the summer season). They are principally birds of the Old World, and the majority are migratory and capable of very protracted flight. In Britain there are twelve regular summer visitors, amongst which are the Blackcap, Whitethroat, Chiffchaff,

Wood-Wren, Willow Warbler, Garden Warbler, and the Grasshopper, Sedge, and Reed Warblers. They are mostly birds of small size and plain plumage, and their song is clear and sweet; the Garden Warbler and the Blackcap especially have beautiful songs. The nest made by members of this family is usually a beautiful little structure, cup-shaped, and often domed. The Tailor-bird, whose wonderful nest has already been mentioned, belongs to the group.

The Mocking-birds are natives of America. They are noted for their brilliant singing and powers of mimicry—hence their popular name. The Common Mocking-bird (*Mimus polyglottus*) is said to be capable of reproducing with remarkable fidelity any sound it hears, from the creaking of a wheel to the song of a nightingale, and will give a faithful imitation of a dog's bark, the sounds of a farmyard, or the human voice.

The familiar little Wren, distinguished by its sprightly manner and upturned tail, is a member of the family *Troglodytidæ*, which has its head-quarters in tropical America. The nest is domed, and often built in thick ivy, or in the middle of bushes and hedges. The song is rather like that of the warblers, but much more shrill.

The Tits, or Titmice (*Paridæ*), are a delightful family of small, energetic birds found in most parts of the Old and New World, with the exception of South America and Australia. There are six species in Great Britain—the Blue Tit, the Great Tit, the Coal Tit, the Marsh Tit, the Crested Tit, and the Long-Tailed Tit. They are active and noisy little birds, flitting restlessly about from tree to tree, uttering their characteristic cry of "*tit-tit-tit*," varied by curious sibilant notes. The majority of the species are non-migratory, and after the nesting season often fly in flocks, frequently in company with other small birds such as Golden-crested Wrens and Nut-hatches. The Blue Tit (*Parus cæruleus*) is perhaps the best known of the family from its habit of making itself quite at home in gardens where there are plenty of trees, particularly if it is provided with suitable food in the shape of coco-nuts, brazil nuts, and pieces of fat hung from the boughs when insect life is scarce in the cold months of the year. The Tit family usually nest in holes in trees or crevices in walls, which they line with moss hair, wool, or fur. Sometimes, like the robin, they will choose curious places for breeding, and utilise pumps, letter-boxes,

or flower-pots, while if suitable nesting boxes are provided the Blue Tits will nearly always take possession of them.

Although accused of pecking fruit and eating buds, Tits certainly do more good than harm in orchards and gardens, by the enormous numbers of insect pests they destroy. They eat insects, and their eggs, larvæ and pupæ, of almost every description, and two or three pairs of Tits will practically clear the trees in the vicinity of their nests of insect pests when they are busy rearing their large and hungry families.

The Great Tit (*P. Major*) is the largest of the family, and, though normally feeding on insects, will sometimes develop murderous tendencies and kill smaller and weaker birds by splitting their skulls with his strong beak.

The Finches (*Fringillidæ*) form one of the largest families of song-birds, numbering about six hundred species, distributed over almost all parts of the world. They are distinguished by the short, stout, conical bill; this, however, varies in different species, and may be longer or occasionally curved. The food of the Finch tribe consists chiefly of seeds, but insects, fruit, and buds are also eaten. They are generally lively and active birds, bold and assertive in their ways, though the habits of the different species vary in many ways. The majority are social and friendly, yet the Common House Sparrow (*Passer domesticus*) is noted for its pugnacious disposition and quarrelsome ways. The flight is usually strong and swift; while on the ground some Finches hop and others run. Most members of this large family frequent wooded districts or open country, a few are found on sandy deserts, others haunt marshes, rocks, or the shore. The song varies in quality from the wonderful melody poured forth by the Canary to the monotonous chirp of the Sparrow. In England many species of the Finch tribe are found, amongst which the Bullfinch with his white-barred wings, glossy black head, grey back, and bright pink cheek, the Chaffinch with his brown plumage, barred wings, and pinkish breast, and the Linnet with its sweet, low song are general favourites. The Greenfinch in the winter-time resorts to the stubble-fields, in company with Sparrows, Yellow Hammers, and others of his race, and in the springtime his curious drawling note is heard in the hedgerows and garden, where his nest is often built. The Brambling, the Redpoll, and the Siskin are chiefly with us in the

winter, though both the latter species sometimes stay to nest. Many of the Buntings are resident in England, and the Crossbill, though somewhat rare, sometimes breeds here, its nest of twigs, moss, wool and hair being placed, as a rule, in a pine-tree.

The Wagtails and Pipits, though differing in their habits, both belong to the same family—*Motacillidæ*. Wagtails haunt running streams and stagnant waters (though some species frequent meadows and cornfields), and nest in holes on the banks, on the tops of pollarded willows, or on ledges of rock. Pipits prefer open spaces covered with rough grass, clearings in woods, or, in the case of the Rock Pipit, rocky shores. The Meadow Pipit (*Anthus pratensis*) is common in meadows, moorlands, and amongst sand-dunes covered with tussocky grass near the shore. It is often called the "Titlark" or "Meadowlark," and from its similarity in appearance and habits is frequently confused with the Skylark (*Alauda arvensis*), which, however, belongs to another family, the *Alaudidæ*. The Skylark is one of the most popular of English birds. Its joyous song is heard not only in the warm summer weather, but frequently during the cold winter months—I have actually heard it singing blithely while a sharp shower of sleet was in progress. It sings, too, sometimes in the night, and though its custom is while pouring forth its song to mount skywards, it does on occasions sing while on the ground or perched on a low bush.

The Flycatchers (*Muscicapidæ*) are a somewhat vaguely defined family of birds peculiar to the Old World, represented in England by the Spotted Flycatcher (*M. grisola*) and the Pied Flycatcher (*M. atricapilla*), both summer visitors. The former is often seen in gardens, and is easily identified by its habit of perching on the top of a post, rail, or stake, suddenly, with a quick, graceful flight, darting off after an insect, and then returning to its original position. It is a graceful though inconspicuous bird, having a quiet, low song; its chief characteristic is the broad, flattened bill beset with bristles which is peculiar to its family.

The Swallows and Martins are, perhaps, the most welcome summer visitors to Britain; their graceful flight and familiar habits of nesting under the eaves of dwellings and in outhouses round about combine to make them general favourites with everyone. The Swallow (*Hirundo rustica*) is larger than a Martin, and is easily

BULLFINCH

distinguished by its glossy black plumage and white breast; while the Martin has a white patch on its back as well as a white waistcoat. The Swallow's tail, too, is longer and more forked than the Martin's. The Swallow prefers to build its nest within some building; in shape it is like an open saucer, the material used being always mud, into which pieces of straw, dry grass, and horsehair are worked, and the inside is lined with feathers. The House Martin's nest is placed under eaves, window-ledges, or any convenient projection; it is fashioned entirely of mud, lined with feathers, and is quite closed, except for the entrance, which is a hole in the side. If undisturbed the Martins will return year after year to the same place, and if the old nest is not too dilapidated will set to work to repair it for the coming brood.

The Sand Martin (*Cotile riparia*) is a smaller bird, ashy-brown in colour, with a white breast across which there is a brownish band. It nests in colonies in sand cliffs, pits, quarries, etc., excavating deep tunnels enlarged at the inner end to make a comfortable nursery.

The Crow tribe is often divided into three sub-families—the True Crows (*Corvinæ*), the Jays and Magpies (*Garrulinæ*), and the Choughs (*Fregilinæ*). The birds of the Crow family are by many authorities placed at the head of the class Aves. Among them we find the most highly developed type of wing, every quill and wing-covert being perfectly formed; the feet, too, are perfectly adapted to the bird's mode of life.

This family has an almost world-wide distribution, some members being found in nearly every part with the exception of New Zealand, the Australian region east of the Sandwich Islands, and New Caledonia. The first division includes the Raven, Carrion Crow, Rook, Jackdaw, and the Nutcracker, all sturdy-looking birds, mostly clothed with black plumage having greenish or purplish tints. The Hooded Crow is distinguished by having its back and lower parts an ashen-grey, and the Jackdaw by the silver-grey feathers on the back of its neck. The Nutcracker is a dark brown bird with black quills and whitish spots.

The Raven (*Corvus corax*) is the largest of the Crow tribe. At one time common in woods and on the hills and crags of Great Britain, it is now rarely found inland, but on the tall sea-cliffs on many parts of the seacoast the bird still makes its home, being

most abundant in the North of Scotland and in the Orkneys and Hebrides.

The Carrion Crow (*Corvus corone*) is a smaller edition of the raven, and very similar in its way. Both birds are voracious feeders, and will eat anything of an animal nature, alive or dead. Their fondness for game and poultry has led to their being driven from many parts of the country, and they frequently attack young and sickly lambs. Shell-fish are also a favourite form of diet with the raven and Carrion Crow; and they have been observed to carry aloft large molluscs and drop them from a height to break the shells.

The Rook (*Corvus frugilegus*) is sometimes confused with the crow, which it very closely resembles in appearance. It may be distinguished, however, by the base of the beak being free from feathers and the skin being covered with scurf, making a noticeable white patch. Rooks, too, are gregarious, while crows live in pairs. Rookeries sometimes contain an enormous number of nests, and in the spring, when the birds are busy building or repairing their nests, it is most amusing, if one does not object to the loud continuous cawing kept up by the colony, to watch their preparations. For Rooks are by no means honest in their way, and they are continually watching for an opportunity to steal one another's sticks, and when one comes flapping up with a fresh twig to add to its nest and finds the latter has been rifled it makes a tremendous fuss, in which all the neighbours join, apparently all declaring, at the top of their voices, that they were not the thieves.

The Jackdaw (*Corvus monedula*) and the Magpie (*Pica rustica*) are both noted for their intelligence and sprightly ways, and the Jackdaw may be recognised by its smaller size and its collar of slaty-grey. It is a distinctly social bird, and may often be seen feeding in flocks in company with rooks. The Magpie, distinguished by its striking black and white plumage and long tail, is common on the moors in Cornwall and Wales, but is rare in other parts of England. In Ireland it is very numerous. It is easy to tame, and makes a most interesting pet, though its inquisitive and mischievous ways are often rather troublesome.

The Jay (*Garrulus glandarius*) is a bird of the woodlands, where its harsh, screeching note is often heard, though, as it has a preference for the denser parts of the woods, its appearance is

JAY

not so familiar. It may, however, sometimes be detected winging its way from one copse to another, and may be recognised by its curious "dropping" flight, and a large white patch just above the tail. The Jay is a handsome bird. The general colouring is a reddish grey, on its head is an erect crest of mottled feathers, and the greater covert feathers of the wing and the winglet are barred with blue, white, and black. Like its allies, the Jay, although it eats much of a vegetable nature, kills and devours small birds, and is especially given to stealing eggs and nestlings from the nests of other birds; and from its propensity for robbing pheasant coops it is held in much dislike by gamekeepers.

The Chough, or "Red-legged Coon" (*Pyrrhocorax graculus*), inhabits wild, rocky regions. It is most common in Wales, the Isle of Man, the Hebrides, and in Ireland, where it builds its nest on the dizzy heights of tall, precipitous cliffs, but it also occurs in some parts of Cornwall and Devon. It is a glossy black bird, slightly larger than the jackdaw, and its long curved bill, its legs, and feet are a bright coral red.

The foreign Passerine birds include many beautiful or interesting species: amongst them are the brilliant-hued Manakins of Central and South America; the Umbrella-bird and Bell-bird, the males of the former having a peculiar umbrella-like crest and the latter an extraordinary fleshy appendage depending from its forehead that can be erected at will—both of tropical America; and the "Wood-Hewers," "Firewood Gatherers," and Oven-birds of the same regions. In Australia there are the remarkable Bower-bird, noted for the playing-grounds it constructs for itself and its mate in the nesting season, ornamented with bright shells, flowers, and other decorations; and the beautiful Lyre-bird, which has gained its name from the shape of the wonderfully plumed tail of the male bird. The Lyre-bird, although most generally classed with the Passerine birds, is, on account of certain anatomical differences, sometimes placed in an order by itself.

CHAPTER XXII

THE ECHIDNA AND THE DUCK-BILLED PLATYPUS

THE Mammalia are the highest of the Vertebrata, and comprise the Monotremes (the animals about to be described), the Marsupials (pouch-bearing Mammals), the hoofed and clawed quadrupeds, the Whales, Porpoises, and Sea-Cows; the Rodents, Bats, and Insectivores (Moles, Shrews, and Hedgehogs), the Lemurs, Apes, and Human species. All are air-breathing throughout life, though many lead a truly aquatic existence. The blood has a high temperature, and, with the exception of the Monotremes, the mammary glands are provided with teats. All, except the Monotremes, are viviparous. The scales of the reptiles and the feathers of birds are replaced in the Mammalia by special epidermal structures, the hairs usually so abundant as to form a thick soft coating of fur.

The **Monotremes** are Mammals without teats, but with a temporary pouch developed during the breeding season, in which the young are hatched, or to which they are transferred after hatching, and into which the ducts of the mammary glands open. This pouch is considered to be the equivalent of a teat, and not of the pouch of the Marsupials.[1] The milk glands communicate with the exterior by a number of small pores situated in a cup-like depression in the skin of the abdomen. The Monotremata are represented to-day by two families, (1) the *Ornithorhynchus*, or *Duck-billed Platypus*, sometimes also called the Water Mole; and (2) the *Echidna*, the Spiny or Australian Ant-Eater, animals which, in addition to the remarkable traits already described, show in their skeleton numerous ancient characteristics.

The Echidna is about a foot long, and the upper part of its short body is covered with strong spines, the rest being hairy, while the front of the head and the long tapering snout are naked. The legs are short and strong, and the toes of the foreleg are armed

[1] *F. R. Beddard.*

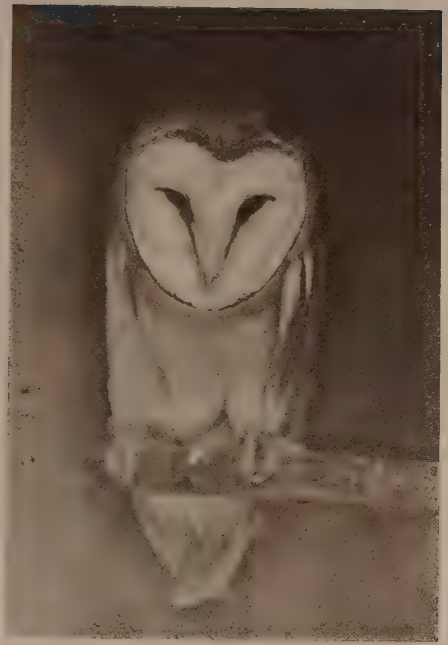
with long strong claws. The tongue is long and flexible, and there are no teeth. Ants are its favourite food, and they are captured in the same way as by the great ant-eaters belonging to the Edentata, the long slimy tongue being poked into the ants' nest. When the ants have collected on the sticky tongue it is taken into the mouth, and they are swallowed. The absence of teeth is made up for by the presence of horny spines on the palate and tongue, and these crush and divert the food into the throat. The long muzzle and slender lower jaw give the skull a very bird-like appearance, which is enhanced by the ball-shaped brain-case. The shoulder and the bones of the upper part of the chest resemble those of the duck-billed platypus. The animal, which inhabits Australia, appears to be stupid and apathetic.

During the breeding season the female Echidna develops a rudimentary pouch formed by an infolding of the skin of the abdomen. The external orifices of the milk glands are little depressions surrounded by hair, and the baby Echidna helps itself to nourishment by placing its snout in these small depressions. Another Echidna, which has three instead of five nails on the fore and hind limbs, is found in New Guinea.

The Duck-billed Platypus is also a native of Australia, and is of all animals that suckle their young the most bird-like ; indeed, so extraordinary is its appearance, that the first specimens brought to Europe were thought to be clever fakes, like the so-called "mermaids," which consist of the head and body of a monkey sewn on to the tail of a large fish. The Platypus has a rather flat body of about eighteen inches in length, and the head and snout greatly resemble those of a duck, while the tail is short, flat, and resembles somewhat that of a small beaver. The feet are webbed and flat, and the greater part of the animal is covered with a dense soft fur of dusky brown colour, darker on the upper part of the body. The animal forms extensive burrows on the banks of the rivers, and leads a thoroughly aquatic life, swimming with ease and grace, and feeding upon molluscs and water plants. The curious beak is flat and broadest in front, where it is rounded. It is hard, and covered with soft, sensitive, and naked skin, and on either side this skin overlaps to form a kind of flexible cheek. When this skin comes to the head it forms a wide fold, which flaps over the front of the head and throat, forming a protection to the face and

eyes when the animal is grubbing in the mud. Within the mouth are capacious cheek-pouches, in which food collected under water can be stored until the animal rises and floats at the surface. The eggs are large-yolked, and develop, so far as concerns their early stages, after the fashion of the eggs of reptiles.

It is impossible here to go into all the technical details of the various anatomical points of interest concerning the Monotremes, but it is interesting to note that both the Platypus and the Echidna have an arrangement of the bones of the shoulder and chest which resembles to a certain extent that of the lizards and of the extinct ichthyosaurus; an arrangement either altogether absent, or only existing as the merest vestiges in the higher Mammals. Indeed, these interesting animals not only represent the lowest extant stage of evolution in the Mammals, but in their anatomy preserve, more markedly than the higher Mammals, traces of the far-off pedigree of their class.



Barn Owl

Little Owl

Duck-billed Platypus

Kangaroo

CHAPTER XXIII

THE MARSUPIALS, OR POUCHED ANIMALS

The Marsupials, or Pouched Animals, comprise the Opossums, the Dasyures (Tasmanian Devil, Thylacine, etc.), the Wombats, Bandicoots, Phalangers, and Kangaroos. All are characterised by the possession of a pouch or *marsupium* within which the young, born in a helpless rudimentary condition, are sheltered. They also are distinguished by a pair of peculiar bones attached to the pubes, called the *epipubic* or *marsupial bones*. This pouch or marsupium must not be confounded with the temporary pouch of the Monotremes. Its walls are supported by a pair of bones (merely cartilaginous and vestigial in the Thylacine), while within it are the distinct mammary nipples or teats.

The presence of the pouch or marsupium, containing the teats, involves many structural and physiological peculiarities which separate the Marsupialia, in a classificatory sense, from the rest of the Mammalia. The Great Kangaroo, which may be considered a fair example of the Marsupials, has, in the female, a set of skin muscles around the pouch, beneath the skin, which close it. The milk, or mammary, gland has four long, slender teats in the pouch, and beneath the skin of it is a muscle called the *cremaster*, which is largely developed; it spreads over the surface of the gland, and its action is to squeeze it and force out the milk through the teat. There is thus protection for the young, and milk is given forth without effort of the young in suckling. The reason for this is obvious. The Great Kangaroo, which is often as tall as a man, is pregnant for about thirty-nine days only, and then a little one, about the size of one's little finger, is born; a helpless, imperfect little creature, practically a larva, for it has one larval organ in the shape of a special sucking mouth. The mother, with the aid of her lips, places it in her pouch, and it fixes on a teat, where it hangs for about eight months, during which time

it grows and completes its development, and about the end of the period begins to look out of the pouch.

On looking at a Great Kangaroo (*Macropus giganteus*) the peculiarities that strike the eye are its small fore-limbs, its very large and long hind ones, and the great thick tail; the smallness of the head, which has rather long ears, and a long dusky brown muzzle, the length of the body, and the beautiful thick, shortish, grey-brown fur. When moving rapidly, the Kangaroo depends upon the powerful hind-limbs alone, bounding along with the greatest ease, and at a high speed. If the short fore-limbs are watched, they will be seen to be able to do a great deal in the way of holding, clasping, and turning things over. The five fingers or digits have a very free movement, and the forearm can also turn and twist about freely.

Of the Brush-tailed Rock Kangaroos Mr. Waterhouse writes :— "Whilst the kangaroos of the plain have the forepart of the body slender and light, great strength in the hinder parts, combined with a long leg and foot, adapting them to fleetness, the tail powerful, and assisting in the support of the long body, we perceive certain modifications in the form and structure of these parts in the Rock Kangaroos which adapt them to their particular habits. The body, more compact in form, requires but little assistance from the tail for its support, the leverage being less; and the feet are, though powerful, comparatively short, and remarkably rough beneath, being thickly covered over this part with hard tubercles, which no doubt prevent the foot from slipping. The nails of the two large toes are shorter than usual, and, indeed, in some of the species, scarcely project beyond the fleshy pads with which the toes are terminated, and on the upper surface of which the nails are placed. A long and slender foot, with long nails, as in the typical kangaroos, it is obvious, would be ill-adapted to an animal which has to leap to and balance itself upon the small ledges of the rocks. The tail is large, but not thickened at the root, as in the plain kangaroos; and, unlike the tail in those animals, it is clothed with long hairs, which, gradually increasing in length from the base of the tail, become very long and bushy at the opposite extremity. It serves to steady the animal in its leaps, and to balance the body when perched in situations which require it, but is of little assistance in supporting the weight of the trunk.

Its muffle, that is to say, the end of the nose, is naked, as in the scrub-frequenting kangaroos."

The Common Tree Kangaroo is an inhabitant of New Guinea, where it lives in the forests, and is no mean climber of trees. There is a kangaroo look about this animal, even when it is seated on a thick branch, but the fur is very different from that of its fellows in Australia; it looks coarse and harsh, and is not unlike that of a bear. The fore-limbs are nearly as large as the hind ones, and are very strongly made; the toes are more equal in size than in the other Kangaroos, and the hands are strong and well made.

The curious little Kangaroo Rats, sometimes called "Potoroos," are about the size of a rabbit, with a compact body, short neck, and rounded ears. The hind-feet are well developed, and the tail is long. The Rufus Kangaroo Rat inhabits New South Wales, and is very common, making a grassy nest in which it rests during the daytime. On being alarmed or pursued, it jumps like a jerboa, with great swiftness for a short distance, and seeks shelter in hollow logs and holes. Its food consists of roots and grasses.

The Wombat is found in South Australia, Tasmania, Bass Strait, and New South Wales. It is by no means an active animal, and, as it shuffles along, looks very much like a miniature bear. About two to three feet in length, the Wombat has a low, plump body, small feet, and strong limbs, ending in broad extremities provided with claws, and a small, stumpy tail. It has a slit-like, imperfect marsupium, and the special peculiarities of its order, such as the marsupial bones, and inflected lower jaw. In its natural state it hides away during the daytime, and quits its retreat at night to dig up and devour grass and roots. In captivity it is generally docile, by no means wanting in intelligence, and becomes very attached to those to whom it is accustomed, and who feed it.

A small marsupial animal, not unlike a little bear, about two feet in length, and without a tail, is the Koala. It is a famous tree-climber, and its stout body and short legs are covered by a soft ashy-grey fur. It feeds on the tender shoots of the blue gum-tree, frequenting the loftiest trees from Moreton Bay to Port Philip. At night it descends from the trees and prowls about in search of certain roots. Its head is rather small, and the fur is short, the upper lip being cleft; and it has a well-developed pouch. The limbs are equal; the fore-feet have five well-made

toes with compressed and curved claws, and the hind-feet have five toes, of which the second and third are shorter than the others, and are united in a common skin. The scientific name Phalangista is derived from this union by skin of the phalanges of the foot:

The Cuscus, or Ursine Phalanger, has a prehensile tail, and is found living amongst the branches of trees in the dense woods of the Island of Celebes. During the daytime it is very lethargic, drowsing quietly in a snug retreat amongst the branches, but brightening up and becoming very active as night draws on. Of greater interest are the so-called "Flying Phalangers," which have all the characteristics of the Phalangers, and, in addition, a skin on the flank of the body, which is extended between the fore- and hind-legs, and serves to sustain the animal in the air when descending from a height. The Yellow-bellied Flying Phalanger (*Petaurus australis*, Shaw) may be taken as the type of the genus, and is fourteen inches long in the body, and nineteen in the tail. The peculiar fold of fur which forms its flying machine is attached to the foreleg as far as the elbow, and all down the legs to the great toe. It is common in all the bushes of New South Wales, particularly those along the coast from Port Philip to Moreton Bay. Mr. Gould states, in addition to this: "In these vast forests, trees of one kind or other are perpetually flowering, and thus offer a never-failing supply of blossoms, upon which the animal feeds. The flowers of the gum-trees, some of which are of great magnitude, are the principal favourites, and, like the rest of the genus, it is nocturnal in its habits, dwelling in holes of trees and in the hollows of branches during the day, and displaying the greatest activity at night while running over the small leafy branches, sometimes even to their very extremities, in search of insects and the honey of the newly-opened blossoms. Its structure being ill-adapted for terrestrial habits, it seldom descends to the ground, except for the purpose of passing to a tree too distant to be attained by springing from the one it wishes to leave. The tops of the trees are traversed at a pace, and with as much ease as if it were on the ground. If chased, it ascends to the highest branches, and performs enormous leaps, sweeping from tree to tree with wonderful address." Another Flying Phalanger is the Sugar Squirrel, which is generally dispersed over the whole of New South Wales where, in common with other Phalangers, it inhabits the magnificent gum-trees.

The **Perameles,** or Bandicoots, are marsupials with long, slender heads; large, long ears, with fleshy lobes; longer hind- than fore-limbs; the tail short in some, long in others, and hairy; and the pouch is directed backwards. They are found in Australia, Tasmania, and some parts of New Guinea, and about eight or nine species are known. They appear to be omnivorous in diet; and unfortunately cause very great damage in cultivated tracts, and consequently are cordially detested by the agricultural settlers.

The **Dasyuridæ** are all carnivorous marsupials, preying upon small quadrupeds and the young of large ones, as well as upon birds and insects. Varying in size from that of a mouse to a small wolf, the members of the different genera of this family are equally variable in the number of their teeth, of the claws, and in the development of the marsupial pouch and its bones. The most notorious member of the family is the "Tasmanian Devil" (*Dasyurus ursinus*), which resembles a large-headed, bluntly-muzzled, very ugly badger in shape. It has the most diabolical temper, and an innate ferocity that is simply astounding, and is absolutely untamable. Though comparatively small of size, its body is about twenty-one inches long, and the tail one-third of that length, it is extraordinarily destructive to all animal life that it can overpower, and was a perfect plague to the early colonists of Tasmania, killing their sheep and poultry wholesale, so that they had no choice but to wage a war of extermination against it, with the result that in the more thickly settled regions the "Devil" is now practically extinct.

The largest of the *Dasyures* is the Thylacine, or Tasmanian Wolf, a dog-like, slim, narrow-muzzled animal, with clean, rather short limbs, a foxy head, and a tail about half as long as the body, which in the males is about forty-five inches in length. It has also been called the "Zebra Wolf" from the twelve or fourteen black bands upon the body. It has a marsupial pouch, but the bones are mere cartilages. It is in fact a marsupial, with some structures which foreshadow those of the more highly developed dog. The Thylacine, like the Tasmanian Devil, made the most voracious attacks upon the flocks of sheep, and consequently had to be hunted down, so that to-day it is only to be found in the most remote mountain regions.

The **Didelphidæ,** or the Opossums, are not found in Australia,

or in Tasmania, or in any part of the natural history province to which those countries belong. They are numerous, however, and are now living on the American continent; but formerly some species inhabited Europe during that geological period which is called the Eocene. They are very rat-like animals with long snout and tail; the latter is destitute of hair, excepting at the root, is covered with a scaly skin, and is prehensile. The Opossums are active, shy, and very intelligent, and their food chiefly consists of insects, small reptiles, birds, and eggs. Living for the most part in trees, they secrete themselves in the hollows of the branches and trunks during the daytime, and sally forth at night. The Common Opossum (*Didelphys Virginianum*) is a large kind about the size of a cat, and its long, large, pointed head, ending in a naked snout, and having eyes encircled in dusky brown fur amongst the white hair and fur of the head, gives it a very cunning and thoughtful appearance. The tail is long and prehensile, the end being white and the rest black, and the legs and feet are brownish. It is a great climber, using its tail to hold on by. Running along the branches, it will often suspend itself by its tail, and give a swing and let go, thus launching its body to a distance, and then it catches at the boughs with its feet. In coming down trees it uses the tail to steady itself, and to prevent too rapid a fall. It is essentially a North American animal, and is found from Mexico to the Southern States. The female brings forth from twelve to sixteen young at a time, and her nest, which is formed of dry grass, is usually at the root of a tree or bush. When first born, the young are said not to be more than a gramme in weight, and blind, naked, and shapeless. They find the teats in the mother's pouch, unless she places them with her mouth, and they cling on so tightly as not to be separated, except by violence. In about five days, so rapid is their growth, they have reached the size of a mouse, and all their parts are developed. They then leave the pouch, returning to it to suckle and when danger appears. During this time the female shows great attachment to her young, and Mr. Waterhouse, from whose work these descriptions are taken, states that she will suffer any torture rather than permit the pouch to be opened. Several species of Opossum inhabit Brazil, Paraguay, Bolivia, Argentina, Guiana, Chili, and Peru.

CHAPTER XXIV

THE SLOTHS, ANT-EATERS, AND ARMADILLOS

The order **Edentata** includes the Sloths, Ant-Eaters, Armadillos, Pangolins, and African Ant-Bear or Aard-Vark, mammals which are collectively characterised by the total absence of front teeth, and in a few instances by the entire absence of teeth from the jaws. Another characteristic of these animals is the simple structure of the cheek-teeth, which are destitute of any trace of enamel,[1] and never form distinct roots, but grow continuously throughout the life of the animal. The order is an extremely interesting one, and may be considered essentially American, for the sloths, ant-eaters, and armadillos are entirely confined to South America.

The Sloth leads an entirely arboreal life, travelling along the branches of the trees body downwards, and with the greatest ease; indeed, it is of all mammals the most perfectly adapted to a life amongst the branches of trees. It rarely comes down to the ground, on which it only walks with some difficulty. It looks slothful enough when asleep, for it then resembles a bunch of rough hair and a jumble of limbs close together, hanging to a branch. Waterton states, however, that the Sloth, when awake, "travels at a good round pace, and were you to see him passing from tree to tree you would never think of calling him a Sloth. Being born up in a tree, living amongst the branches, feeding on leaves, and finally dying amidst the foliage, and enjoying life as much as any other animal, its structure and conformation are, of course, admirably suited for this arboreal existence. Its power of grasp is great, and is assisted by the great bent claws as it hangs by its feet when asleep, and also often when it is dead. One, which was much frightened by being taken from the forest, had a pole placed near it at a little distance from the ground, on two supports.

[1] A rudimentary enamel-organ has been discovered to exist in an armadillo.

It clung directly to the pole and hung on. Some years ago I kept a Sloth for several months. I often took him out of the house and placed him on the ground, in order to have an opportunity of observing his motions. If the ground were rough he would pull himself forward by means of his forelegs, at a pretty good pace, and he invariably shaped his course towards the nearest tree; but if I put him upon a smooth and well-trodden part of the road, he appeared to be in trouble and distress. His favourite abode was the back of a chair, and after getting all his legs in a line upon the topmost part of it, he would hang there for hours together. The Sloth, in its wild state, spends its whole life upon trees, not upon the branches, but under them; he moves suspended from the branch, he rests suspended from it, and he sleeps suspended from it; hence his seemingly bungled conformation is at once accounted for. One day, crossing the Essequibo, I saw a large Two-Toed Sloth on the ground upon the bank, and although the trees were not twenty yards from him, he could not make his way through the sand in time enough to make his escape before we landed. He threw himself on his back and defended himself with his forelegs. I took a long stick and held it for him to hook on, and then conveyed him to a high and stately mora. He ascended with wonderful rapidity, and in about a minute he was almost at the top of the tree. He now went off in a side direction, and caught hold of the branch of a neighbouring tree, and then proceeded towards the heart of the forest."

The length of the fore-limbs is very striking in the Sloth, and the bones of these limbs are more solid than those of most mammals. The wrist and hand are long and narrow, and terminate in three or two strong curved claws, according to whether the animal happens to be a Three-Toed Sloth, or Ai (*Bradypus tridactylus*), or a Two-Toed Sloth, or Unau (*Choloepus didactylus*). The fur is shaggy, and has a peculiar greenish tinge, which is not due to the colour of the hair, but to the growth of a small plant (an alga) upon it. The Three-Toed Sloth is remarkable in possessing no fewer than nine vertebræ in the neck, which enables the animal to turn its head almost completely round without any movement of the body. The two species of Two-Toed Sloth have, respectively, six and seven vertebræ in the neck, and are very similar in their general appearance and habits to their three-toed relation. Dr.

Siemann states that a species occurring in Nicaragua "has almost exactly the same greyish-green colour as *Tillandsia usneoides*, the so-called 'vegetable horsehair' common in the district. If it could be shown that it frequented trees covered with that plant, there would be a curious case of mimicry between the Sloth's hair and the *Tillandsia*, and a good reason why so few of these Sloths are seen."

The Great Ant-Eater (*Myrmecophaga jubata*) is a large and handsome animal, with long, shaggy, greyish-black hair, and a broad white stripe across the shoulder. The head is narrow, and ends in a long, flexible, slender snout, with a long, worm-like, round tongue; and the jaws are destitute of teeth. The huge bushy tail is flattened at the sides, and has a fringe of very long, strong hair. The animal measures over seven feet in length from the end of the snout to the tip of the tail. Its limbs are stoutly built, and the forelegs are provided with powerful claws, which are used in breaking down the strong ant-hills, upon whose inhabitants the Ant-Eater feeds. When standing or walking, the claws of the front feet are bent inwards and under, not touching the ground with their tips, and this peculiarity gives the animal a curious shuffling, hobbling gait. The skull is very low and long, and the framework of the tongue is as important as that of the jaws, which are without teeth. The palate is long—so long, in fact, that where the long nose cavity opens into the throat, in the skeleton, certain bones, called pterygoid or wing-shaped, form part of its boundary. This is unusual amongst the Mammalia, and Huxley observes that it is only found in some of the Whale tribe (*Cetacea*).

Don Felix d'Azara, in his "Natural History of the Quadrupeds of Paraguay," gives many interesting details concerning the life of this remarkable animal, and states that it is slothful and solitary in its habits, spending a great proportion of its time in slumber. "The female bears but a single young one at a birth, which attaches itself to her back and is carried about with her wherever she goes, rarely quitting her, even for a year after it has acquired sufficient strength to walk and provide for itself. In his natural state the Ant-Eater lives exclusively upon ants, to procure which he opens their hills with his powerful crooked claws, and at the moment that the insects, according to their nature, flock from all quarters to defend their dwellings, draws over them his long, flexible tongue

covered with glutinous saliva, to which they consequently adhere; and so quickly does he repeat this operation, that we are assured he will thus exert his tongue and draw it in again, covered with insects, twice in a second. He never actually introduces it into the holes or breaches which he makes in the hills themselves, but only draws it lightly over the swarms of insects which will issue forth, alarmed by his attack. It seems almost incredible that so robust and powerful an animal can procure sufficient sustenance from ants alone; but this circumstance has nothing strange in it to those who are acquainted with the tropical parts of America, and who have seen the enormous multitudes of these insects which swarm in all parts of the country to that degree that their hills often almost touch one another for miles together." The Great Ant-Eater is found in all the warm and tropical parts of South America, from Colombia to Paraguay, and from the shores of the Atlantic to the foot of the Andes, and is terrestrial in habit.

The Tamandua (*Tamandua tetradactyla*) is much smaller than the great ant-eater, has a prehensile tail, and leads an arboreal life. This animal has a long head and snout, small mouth, and rounded ears. Its fore-limbs are very stout, and the hind ones rest on rather a long sole. The fore-claws are bent on the hands, and the animal walks on their outer and upper surface, using them also to clasp and to hang on by in climbing. This little ant-eater is an inhabitant of the dense forests of tropical South America, in Paraguay and Brazil. The female is said to produce but a single cub at a birth, and to carry it about on her shoulders for the first three or four months. When irritated, the Tamandua gives off a most pungent and unpleasant odour.

The Two-Toed Ant-Eater (*Cyclothurus didactylus*) at first sight appears to resemble a sloth with a prehensile tail; and its round head, furry body, and two claws on the front limbs, add to the resemblance. It frequents the forests of Brazil, Costa Rica, and Honduras, where it leads an arboreal existence, preying upon the swarming insect life, and climbing from branch to branch, and tree to tree, by means of its stout claws and prehensile tail. In the general shape of the body it rather resembles a miniature tamandua, the little animal being about the size of a full-grown squirrel. Von Sack, who kept a couple of these little animals

under observation, states that "one was of a bright yellow colour, with a brown stripe on the back, the other was silvery-grey and darker on the back. The hair of each was very soft and silky, a little crisped; the head was small and round, the nose long, gradually bending downwards to a point; it had no teeth, but a very long, round tongue; the eyes were very small, round, and black; the legs rather short; the fore-feet had only two claws on each, the exterior being much larger and stronger than the interior, which exactly filled the curve or hollow of the larger one; the hind-feet had four claws of moderate size; the tail was prehensile, longer than the body, thick at the base, and tapering to the end, which, for some inches on the underside, was bare."

The Cape Ant-Eater (*Orycteropus capensis*), or Aard-Vark, is a strange-looking creature, rather pig-like in appearance, whence its Boer name of Aard-Vark (literally earth-pig). It is a heavily-built animal, the stout body being covered with a rather scanty growth of coarse hair; the snout is long, with round nostrils at its end, and very pig-like in appearance; while the ears are long, erect, and pointed, and the tail, which is very thick close to the body, gradually tapers off. The front limbs are four-toed, and the hind limbs five-toed, the claws being powerful and strong, well adapted for the work of digging in the ground, and breaking open the nests of the ants and termites, or white ants. The tongue is long, narrow, and slender, and the back parts of both the upper and lower jaws carry five teeth on each side, twenty in all. There are no permanent front teeth. This strange-looking animal is nocturnal in its habits, making an underground burrow to live in and to sleep in during the daytime. Then at night it comes forth cautiously from its retreat, for it is a shy animal, and at once begins to dig with its strong claws into a neighbouring ant-hill. The infuriated insects rush up to the opening, into which the Aard-Vark protrudes his long, slimy tongue, which quickly becomes covered with ants, when it is returned into the mouth; this process is repeated again and again, until the animal's appetite is satisfied.

All the Pangolins, or Scaly Ant-Eaters (*Manis*), are inhabitants of the Old World, like the aard-vark, and are found in Asia and Africa. They are absolutely toothless, and the tongue is worm-like, round, and very long. They range in size from two to nearly

five feet in length, with long tails; and their body, limbs, and tail are covered with numerous large, somewhat angular, and sharp-edged scales, as with armour. The scales overlap each other like tiles, and the free part pointing backwards is bluntly angular or rounded at the tip. When the Pangolin is on its feet walking, these scales form a very close and impenetrable covering, being doubtless of great use to it as a means of defence. When the animal is alarmed or danger threatens, it rolls itself up like a ball, and sticks up its scales, offering their sharp edges to the enemy. In walking the front claws are bent under, so that the whole weight of the front of the body is thrown on the back of the claws. The hind-feet are placed flat, and the sole and under part of the claws sustain the hind-quarters. The joints of the five fingers of the fore-feet are so arranged that they can bend downwards only, and indeed they are more or less permanently bent, being kept in that position by strong ligaments. This assists the digging powers of the claws, which are, moreover, forked at their points in some species, and the wrist is rendered very strong by having the joints between two of its bones abolished. Every structure in the fore-limbs is adapted to promote easy and powerful digging. The Pangolins, like the aard-vark and the South American ant-eaters, break open the nests of the true ants and the so-called white ants or termites, and the swarming insects are caught on the long, slimy tongue, and thus conveyed to the mouth.

The Armadillos are inhabitants of South America, and are more or less covered with a hard bony crust, separated into shields and bands, which are more or less movable owing to the presence of special skin-muscles. This remarkable covering is, according to Professor Huxley, strictly comparable to part of the armour of the crocodile; and the Armadillos are the only mammals possessing such a structure. The shields and bands are formed of many scales, or scutes, which are ossifications of the skin. In the most perfectly armoured Armadillos there are four distinct shields and a set of bands. Of the shields, one covers the head, another the back of the neck, a third protects the shoulders like a great cage, and the fourth arches over the rump like a great dome. The movable bands cover the back and loins, and are between the third and fourth shields. The tail may be invested by complete bony rings and scattered scales. So that these remarkable little animals

are veritable armoured knights of the mammalian world. They are rapid burrowers, the limbs and toes being admirably adapted to this mode of life, and they appear to have a somewhat omnivorous appetite, feeding upon insects, carrion, etc. While there are no front teeth present, they have single cylindrical molar teeth in the back of the jaw, of which, according to the species, there are from seven or eight to twenty-five on each side of each jaw, so that the term *Edentata* is singularly inapplicable to the Armadillos.

The Great Armadillo (*Dasypus gigas*) lives in the forests of Brazil and the northern parts of Paraguay and Surinam. Including the tapering tail, the animal measures some four feet in length. Its claws are powerful, and the fore-limb and hand are singularly modified to enable the animal to dig rapidly; and the speed with which the animal burrows into the ground, making long and deep excavations in the soil, is really astonishing. It feeds upon roots, fallen fruit, and insects, and is also said to have a liking for carrion.

The Poyou, or Yellow-footed Armadillo (*Dasypus sexcinctus*) is an active little creature, measuring some sixteen inches from nose to tail. It is a native of Brazil and Paraguay, where it is fairly common. It has, for its size, a large head, flat, nearly triangular on top, with pointed erect ears, and bright, sharp eyes, giving the face an intelligent expression. Although the legs are short, they are very strong, and the little animal, when chased, dashes off at a surprising speed, and with its forearms burrows into the ground with great rapidity. It is a bold, restless little animal, and when disturbed comes out of its burrow and makes a curious grunting noise rather like that made by a little pig. It soon becomes tame in confinement, and makes a most amusing and interesting little pet.

The Peludo, or Hairy Armadillo (*Dasypus villosus*), is smaller than the poyou, and inhabits the pampas north of the Rio Plata, and Chili. Externally the chief point of distinction from the poyou —apart from its smaller size—is the long, silky, half bristly, and abundant black hair. Of its habits, Don d'Azara writes:— "In an expedition which I made into the interior, between the parallels of 35° and 36° S. longitude, I met with vast multitudes of this species of armadillo, so that there was scarcely an individual of the party who did not daily capture one or two at least; for,

unlike the poyou, which moves abroad only at night, this animal is to be found at all times, and, if alarmed, promptly conceals himself if not intercepted. In March and April, when I saw them, they were so extremely fat that their flesh surfeited and palled the appetite; notwithstanding which, the peons and soldiers ate them roasted, and preferred them to beef or veal. This hairy armadillo, like others of the genus, has undoubtedly a very acute sense of smell, since it scents the carcasses of dead horses from a great distance, and runs to devour them; but as it is unable to penetrate the hide, it burrows under the body until it finds a place which the moisture of the soil has already begun to render soft and putrid. Here it makes an entrance with its claws, and eats its way into the interior, where it continues feasting on the putrid flesh till nothing remains but the hide and bones."

The Ball Armadillo (*Dasypus* [*Tolypeutes*] *apar*) is a small and very beautifully ornamented little animal, which has three free central bands and a short tail, with large fore and aft shields. It rolls itself up, on the slightest alarm, so that the great shoulder and croup shields meet, the head and tail fitting in exactly, in front, thus closing up the body safely. It is an active, light-footed little animal, rarely more than fifteen inches long, and is found in Brazil, Paraguay, and Buenos Ayres.

From the above brief description it will be seen that the Edentates form a very remarkable order, interesting on account of the different external appearances of the species, their diverse modes of life, and singularly restricted localities. It would appear that there has been much degeneration in some of the anatomical characters of many species, especially in those whose foot bones and neck vertebræ have joined more or less. Equally interesting is the singular resemblance which some species present, in various points of their anatomy, to the lower animals, as is also their wonderful relation, in point of structure, with a number of extinct Edentata, most of which were of gigantic proportions, as for example the armadillo-like glyptodon, which grew to sixteen or seventeen feet in length, and whose fossil remains have been found in South America, and so far north as Texas and Mexico. The megatherium was a giant ground sloth as big as an elephant, and its fossil remains are found in the Pleistocene gravels of South America The mylodon, another huge ground sloth, about as

big as a very large bull, lived at the same time as the megatherium, and, in the light of recent important researches, appears to have survived into quite modern times, for portions of the skin covered with long hair of a light yellowish-brown colour, and actually showing bloodstains and serum, have been discovered. Dr. Nordenskjold found at the end of the fiord of the Ultima Speranza, in Southern Patagonia, a vast cave from which some white settlers living in a farm close by had obtained an enormous piece of the skin of the mylodon, which, though dry, was undecomposed and in perfect preservation. Human bones as well as those of the mylodon have been found in the same cavern, many of the bones of the latter having been unmistakably cut or broken by the human inhabitants of the cave, who it is surmised kept these animals alive in the cave and killed and devoured them, splitting their bones to obtain the marrow. When the last of these gigantic ground sloths, links with the prehistoric past, died it is impossible to say, but that it ceased to exist at a comparatively recent date would appear certain from the evidence that has so far been obtained.

CHAPTER XXV

THE WHALES, DOLPHINS AND MANATEES

THE **Cetacea,** or Whales and Dolphins, hold a primitive position among the mammals, their nearest relatives appearing to be the Edentata. As Professor Beddard points out, there are quite a number of striking anatomical features in which a likeness is shown between these apparently diverse orders of mammals. The Whales form one of the most extraordinary groups of the mammals, for they are warm-blooded, air-breathers, and sucklers of their young, and are most remarkably adapted for life in a watery element. Most of the Cetaceans are of a club shape, with compact, more or less cylindrical body, and long, narrow, tapering tail. The head is in such continuity with the body that of neck there seems nothing. In some there are upright fleshy back fins, in others these are lacking. The gristly caudal fin is horizontal, and not upright or rayed like a fish's. The body is smooth and devoid of hair. The eye is remarkably small, and the ear orifice is so diminutive as to seem deficient. The head is either rounded, massive, or has a long snout. There are no hind-limbs, and only in the enormous Whalebone Whales have the rudiments of any been found. Small pelvic bones, however, are present, embedded in the flesh at the setting on of the tail. The fore-limbs, which are ordinarily termed "flippers," have the usual bones extremely broadened and flattened; the free part—equivalent to the hand—being encased in a rigid or stiff nailless membrane; and in a few instances the phalanges are exceedingly numerous, producing a long-fingered peculiarity met with in no other mammal. The nostrils, often a single crescentic aperture, open right on the top of the head, and, except in the Sperm Whale, not in front as in all other mammals. The lungs are large, and by an extraordinary modification of the larynx, and the ability to compress firmly or close the blow-hole (nasal aperture), the Cetacean is enabled to

swallow food under water without the latter entering the lungs: The familiar "blowing" or "spouting" takes place at intervals as the animal reaches the surface, and is part of the act of respiration.[1] The Cetacea includes the mightiest creature that exists or has ever lived, the gigantic Sibbald's Rorqual, which is eighty-five feet in length.

A remarkable Cetacean which is never found in salt water, or at best only in the brackish waters of the Sunderbunds, and inhabits the rivers Ganges and Indus, from their mouths upwards, is the Susu, or Gangetic Dolphin (*Platanista gangetica*). It is sooty black in colour, and measures from six to twelve feet in length. It has a somewhat globular-shaped head, with a long, narrow, spoon-shaped snout, the upper and lower jaws of which are implanted with numerous teeth, pointed and conical in front, while the back ones are narrower and flattened. The Susu frequents the deep reaches and creeks of the river, occasionally coming to the surface to blow, and, although often heard, is but seldom captured. Its food appears chiefly to consist of fish, shrimps, molluscs, etc., for which it hunts in the muddy ooze of the river bed.

The Inia, or Amazon Dolphin (*Inia Geoffrensis*), is another remarkable fresh-water dolphin. Exceedingly numerous throughout the Amazons, Bates states that it is nowhere more plentiful than in the shoaly water at the mouth of the Tocantins, especially in the dry season. The Indians have a story that the "Bouto," as they call this creature, "once had the habit of assuming the shape of a beautiful woman, with hair hanging loose to her heels, and walking ashore at nights in the streets of Ega, to entice young men down to the water. If anyone was so much smitten as to follow her to the water-side, she grasped her victim round the waist and plunged beneath the waves with a triumphant cry." It is held in veneration, and on this account the Indians can hardly be induced to harpoon it. The animal is about seven or eight feet in length, of a bluish colour above, passing into a full flesh-tint beneath. The head is furnished with a long beak, there is a kind of keel-shaped dorsal fin, and the flippers are of fair size, broad at their base and then tapering.

[1] These notes on the general structure of the Cetacea, and the subsequent description of the different species, have been largely compiled from the writings of Professor James Murie.

The Bottlehead or Common Beaked Whale belongs to what are called the *Ziphoid Whales*, the common characters of which are long narrow beaks, elevated heads, a small but well-marked dorsal fin placed behind the middle of the back, short flippers with rounded extremity, a pair of short throat furrows of a V-shape, a single somewhat crescentic blow-hole placed crosswise in the middle of the head, absence of or only rudimentary teeth in the upper jaws, and one or two pairs of very peculiar teeth in the lower jaws. The living forms are rare, and range from fifteen to thirty feet in length. They appear to be the descendants of an ancient family that existed in large numbers at the geological period when the Norfolk Crag was forming, for their fossil remains are very numerous in these formations. The Bottlehead Whale is a constant visitor to our shores, and inhabits the breadth of the North Atlantic, feeding chiefly on cuttlefish and the soft-bodied holothurians. It ranges from twenty to forty feet in length, according to age and sex, and is of a uniform blackish hue. The upper jaw is toothless, and the lower jaw has only two or three small concealed teeth. In the autumn the female gives birth to a single young one.

Next to the Greenland Whale, the Sperm Whale, or Cachalot, is by far the most important animal of the whale tribe from a commercial point of view. It is a powerful monster, attaining a size varying from forty to seventy feet in length. It is black above, lighter on the sides, and silver-grey beneath. Its head is of enormous proportions, forming nearly half the bulk of the animal. The snout is extraordinarily dilated and terminates abruptly; the upper jaw quite overhangs the lower, and the bones of the latter are united close together for a long distance, and are furnished with from twenty to thirty teeth on each side. When the lower jaw is closed the teeth fit into hollows in the upper lips, in this respect somewhat resembling what takes place in the crocodile's mouth; but besides the remarkable lower jaw, the Sperm Whale's skull rivets attention from the extensive basin-shaped spermaceti reservoir. The throat is very large as compared with that of the Greenland Whale. The Sperm Whale is met with in all the oceans, from the Polar to the Antarctic, though it chiefly inhabits the tropical and subtropical seas. It appears to be a migratory animal, though its migrations are by no means clearly

understood. It is a gregarious creature, "schools" of a dozen to fifty or sixty being occasionally seen. At other times great fellows are found here and there on lonely pilgrimages, or a few together *en route* to fresh feeding-grounds. Adult females or those with young in their company evince a strong affection for each other, and when one is killed or injured the parents or companions hover about and even render assistance. The steady "fishing" of these gigantic animals for many years has greatly thinned their numbers, and with the improvement in the apparatus for their capture and slaughter now in use they are a race of animals doomed to rapid and complete extinction.

The Dolphins and Porpoises, forming the family **Delphinidæ**, embrace the greater number of existing species of whales, and the group possesses considerable diversity in outward form and anatomical details. Nearly all have dorsal fins. Excepting in the Narwhal, numerous teeth exist in both jaws, and the lower jaw is united only for a short distance; there is no distinct skull crest behind the nasal orifice, and the neck vertebræ in most are soldered together.

The Caaing, or Pilot Whale, is one of the best known of the whales that frequent the coasts of Great Britain, large herds having often been run ashore in the Shetlands, Orkneys, and Firth of Forth. The body is cylindrical, tapering to the tail; the dorsal fin is high, placed at the middle of the back, and the flippers are unusually long and narrow. The head is quite characteristic, having the form of a massive boss. The adult animal averages from sixteen to twenty-five feet in length, and is of a jet black colour, except on the abdomen, which is greyish or whitish in colour. When a "school" of these whales is seen to enter the bays of our northern coast the fishermen set off in their boats and form a cordon seawards; and then by gunshots, shouts, and splashings drive the frightened animals shorewards, where they are quickly dispatched.

The Common Porpoise is frequently to be met with off our coasts, and a prettier sight can hardly be conceived than a large shoal frolicking, dashing, jumping in all manner of fantastic curves, in the sparkling summer sea. The animal has a wide distribution, being found all over the Mediterranean, Pacific, Atlantic, and Arctic regions; and it appears to be migratory in its habits, probably following the migration of the shoals of herring, mackerel, and

pilchard, as it is a true fish-feeder. Its average length is four or five feet, though it often measures more. The colour slightly varies with age and sex; usually it is a polished bluish-black tint on the upper parts, merging into a pink or mottled grey or whitish beneath. The head is roundish, and the dorsal fin and flippers are both of moderate dimensions.

The Killer Whale, or Orca (*Orca gladiator*), ranges in size from eighteen to thirty feet in length, and its fierceness and voracity are unbounded, so that it is feared not only by the porpoises, white whales, seals and sea-lions, and the walrus, but even by the great sperm and Greenland whales. Three or four Killer Whales will not hesitate to grapple with the largest baleen whale, and literally tear it to pieces. They haunt the Pacific sealing-grounds, where they continually swim about and swoop down and carry off the unwary youngsters; and so fierce are they that even the usually pugnacious large male sea-lions hastily retreat ashore and give them a wide berth. The great swiftness of these Killer Whales is best realised by the fact that they pursue and overtake the quick-swimming dolphins, literally swallowing them alive. They are not gregarious in the sense of being found in large herds, but follow their prey in small squads. They have an evenly rounded head, blunter than the porpoise's, and the upper jaw is a trifle longer than the lower. Their flippers are broad and oval-shaped, and what renders them peculiar and easily recognised is their greatly lengthened dorsal fin. Though slightly varying in colour, they are usually glossy black above and white below. Their capacious mouth is provided with eleven or twelve teeth on each side of both jaws, and each tooth is most powerful, conical and slightly recurved.

The Common Dolphin (*Delphinus delphis*) averages six to eight feet in length, and is black above and brilliantly white beneath; the teeth vary in number from forty to fifty on either side of both upper and lower jaws. Dolphins feed on fish, medusæ, and crustaceans, and habitually congregate in large herds. They are frequently seen off our coasts, and seem to take a delight in following and gambolling around vessels. Indeed, it is a most delightful and interesting sight to watch their frolics from the deck of a ship, as for an hour or two, or even longer, they will play a sort of game of follow-my-leader round the vessel, jumping,

diving, racing through the water, and giving the most wonderful exhibition of their perfect adaptation to their environment.

The Narwhal, or Sea-Unicorn (*Monodon monoceros*), is a most remarkable whale on account of its so-called horn, or rather tusk, or, still better, enormously developed canine tooth, which looks like a solid rod of ivory, tapers from root to tip, has a kind of striated spiral surface, and is often from five to seven feet or more in length, so that the Narwhal is easily the proud possessor of the longest tooth in the mammalia. The adult animal varies from ten to sixteen feet in length, and has a blunt, short head, no dorsal fin, and very small flippers. It is essentially a northern form, insomuch that it frequents the coasts of Greenland, Spitzbergen, and Siberia, occasionally appearing off the coasts of Scandinavia and Britain. The Narwhal possesses only two teeth—the greatly developed or left canine, and within the jaw on the right side the rudiment of a similar tooth which seldom is protruded; although in certain rare cases, instead of one, the two tusks are developed. The great single tooth in the upper jaw is quite rudimentary in the female.

The Whalebone Whales (*Mystacoceti*) are distinguished from the toothed whales by their upper jaws being provided with baleen plates instead of teeth; in early life, however, rudimentary teeth occasionally are present, but these never project beyond the gums. Their skulls are symmetrical, and not distorted as in the toothed whales, and there is a double aperture to the blow-hole. The separate bones in the lower jaw arch widely outwards. The upper jaws are relatively narrow and project forwards at the same time with a great fore-and-aft arch, but are encompassed by the lower jaw arches. The head is proportionally of immense size, and admits of an extraordinarily capacious mouth. The palate is but a narrow median line, and the huge mouth little else than an enormous dome of whalebone plates whose inner lower margins are frayed. Thus, while the whalebone is longer than the depth of the closed mouth, it nevertheless is accommodated by being tucked in below at its flexible extremities. A great, broad, massive tongue fills the interspace between the lower jaws. The whalebone blade of dense horny-like material is in the early stages composed of a brush of hair-like bodies, which, lengthening, solidify and assume the hard horny appearance afterwards known as "the

blade." The gum of the upper jaws has a series of these plates, the one in front of the other, which elongate as growth proceeds, but leave the free extremity with a fringe of separate hairs. Again, the blade towards the gum is embedded in a fleshy substance similar to the roots of our finger-nails. It grows continuously from the roots, like the latter, and in many respects corresponds save that the free end is always fringed. Baleen, therefore, though varying from a few inches to a number of feet long, in fact approximates to a series of, so to say, mouth nail-plates, which have a somewhat transverse position in the cavity of the mouth, and thus their inner split edges and lower free ends cause the mouth to appear as a great hairy archway, shallow in front and deeper behind.

The Greenland or Right Whale (*Balæna mysticetus*) attains a length of fifty or sixty—rarely seventy—feet in length. The females are said to be larger and fatter than the males, and produce one young one—rarely two—in the spring of the year, which they suckle for a twelvemonth, and exhibit the greatest affection for. The bulky body is largest about the middle, tapering rather suddenly towards the tail, the flukes of which are occasionally over twenty feet from tip to tip. The flipper is short and broadish, while the great head is a third of the entire length of the animal. Gregarious in habit, these whales were at one time seen in herds, but persistent hunting has thinned their numbers, so that now they are generally met with in twos or threes. Among the most remarkable peculiarities of this whale are the nature of its food and its mode of feeding. In the high latitudes there float immense quantities of a small soft-bodied mollusc (*Clio borealis*) and also swarms of minute crustacea and jelly-fishes of various kinds. The minute invertebrate animals feed upon the even smaller microscopic floating forms of life, and particularly on the unicellular plants called diatoms, and in turn form the food of the whale; so that in a secondary manner this immense animal is sustained by incredible numbers of these microscopic plants, of which more than a thousand could be placed side by side upon a shilling without crowding! When the whale opens its mouth to feed, the whalebone springs forwards and downwards so as to fill the mouth entirely. When in the act of shutting it again, the whalebone being pointed slightly towards the throat, the lower jaw catches it and carries it up into the hollow of the mouth. The animal in opening its mouth gulps a

quantity of the water containing its minute marine food, and then closing the mouth the liquid escapes, and the small organisms are entangled in the hairy meshes of the ends of the whalebone or baleen plates.

The Manatees (**Sirenia**) are a small group of marine mammalia, which, on account of their singularly isolated position, are of peculiar interest to the zoologist. Partly from their aquatic habit and some outward resemblances, they were classed by Cuvier among the whales, but Illiger signalised and defined them as a separate sub-order, the Sirenia, with an organisation differing distinctly from that of the whales; while later de Blainville strove to show that they possessed certain elephant-like structures which entitled them to close proximity to these creatures. Although still placed in the immediate vicinity of the whales, it is now generally admitted by zoologists that the likenesses which they undoubtedly show to the Cetacea are of an adaptive kind and related to their mode of life. Among the general characters of the Sirenia is a long, compact, cylindrical body, without a back fin, narrowing towards the tail, which terminates either whale-like, in forked flukes, or beaver-like, in a great flat expansion. The fore-limbs are encased, flat, and flipper-like, exceedingly flexible, and more completely formed than in the whales. The extinct and fossil Halitherium alone is known to have possessed rudiments of hind-limbs, though pelvic bones are present in all. The skin is dark, elephant-like, tough, and may be sparsely covered with hair, or smoothish and whale-like. The two mammæ are on the breast close to the armpits. The Sirenia are animals of slow habit, and are most inoffensive, feeding solely upon aquatic vegetation.

Steller's Rhytina (*Rhytina Stelleri*), sole representative of the genus, is now extinct. When the Russian, Behring—after whom the Straits are named—first visited that region and the neighbourhood of Kamtschatka, there existed a huge animal, of which, under the name of Manatee, or Northern Sea Cow (*Vacca marina*), the naturalist Steller, who accompanied him, gave a classical account. It had a small oblong head, a full bristly snout, and a dark-coloured body protected by a rugged, gnarled, warty, hairless skin. The four limbs were quite short and stumpy, and the tail ended in a horizontal, stiff, half-moon-shaped, narrow fin-blade fringed with a fibrous, whalebone-like material. It had no teeth,

but horny, almost bony plates, corresponding to the horny gum-pads of the dugong and manatee, served the purpose of mastication. According to Steller, it attained a length of from twenty to twenty-eight feet. Though stupid, voiceless animals, they were of a very affectionate disposition, and were readily tamed, even allowing themselves to be handled. They appeared in families, each consisting of a male, female, one half-grown cub, and a cub born in autumn; and sometimes these families united into great herds. As they were found to be very good eating, Steller unfortunately recommended them as articles of diet to the sailors; and so faithfully was his advice observed by the natives and seamen, that within twenty-seven years of his first visit the last Rhytina was killed, namely in 1768.

The Dugong (*Halicore Dugong*) is a living species, usually ten to twelve feet in length, and with a fairly wide distribution, being found from the Red Sea and the East African coasts to the west coast of Australia; it is occasionally met with on the coasts of Mauritius, Ceylon, and the Indian Archipelago, though its numbers are fast diminishing, and it appears doomed soon to complete extinction. Outwardly it differs from the Rhytina in being smooth-skinned, and in having the fore-limbs longer, and the tail semilunar, but deeper and less fluked, and not marginally split. In colour it is slaty-brown or bluish-black above, and whitish beneath. It frequents the shallow smooth waters of the bays, inlets, and river estuaries where fucus and other seaweeds grow in abundance, and there it feeds in a leisurely fashion.

The Manatee inhabits the coastal waters and rivers of the African and American continents. In Africa it ranges along the west coast, and ascends the Senegal, Niger, Congo, and other rivers. In America two forms are supposed to exist, one being found in Florida, the other in Surinam, Guiana, Jamaica, the Amazon and its tributaries, and the various rivers, bays, and inlets of the tropical American coast, browsing on the aquatic vegetation, but having apparently a preference for fresh-water plants. In their general habits they appear to resemble the dugong and rhytina. The full-grown Manatee is from ten to twelve feet in length. Its long body terminates in a thin, wide, shovel-shaped, fibrous, horizontal tail; and the fore-limbs, or flippers, have diminutive

flat nails. The skin of the body can only be compared to that of the elephant, not in colour alone, but also in its coarse, wrinkly texture, and widely scattered, delicate, but long hairs.

Of more or less gentle disposition, inoffensive and lethargic in habit, the existing Sirenia are an order of animals inevitably doomed to total extinction ere long, unless some more or less drastic form of legislation can be adopted for their protection. It seems sad that these most interesting and harmless animals, which in the light of recent geological research may eventually prove, in spite of their present-day aquatic habits and somewhat whale-like appearance, to be related to the elephants and hoofed quadrupeds, or Ungulata, should be allowed to become extinct.

CHAPTER XXVI

THE UNGULATES, OR HOOFED QUADRUPEDS

The Ungulata represent a very large and important group of mammals, comprising the Elephants, Hyraxes, Hippopotami, Pigs, Ruminants (Camels, Sheep, Oxen, Goats, Antelopes, Giraffes, and Deer), the Tapirs, Rhinoceroses, and Horses; which may all be defined as terrestrial animals possessing hoofs rather than claws or nails, and chiefly, if not entirely, vegetarian in habit.

The African and Indian Elephants are the only two living species belonging to the order **Proboscidea**, and these two survivors of a once numerous and widely distributed order occupy to-day a zoological position of peculiar isolation, though through a most interesting series of fossil forms their ancestry has been traced to a probable origin among primitive hoofed or ungulate animals. On account of their large size and singular sagacity, the Elephants attracted the attention of man in the earliest times, and were always looked upon with feelings of awe and reverence.

While the general aspect of the Elephant is so familiar as to require no description, there are certain anatomical points of considerable interest to which brief reference must be made. The skull of the Elephant is remarkable for its great size and the comparatively small cavity occupied by the brain. The latter is small in comparison to the size of the animal, in bulk not much exceeding that of man. Although the bones of the skull are so large, they are not solid, their interior being occupied by hollows, divided from each other by thin partitions, by which means the skull is rendered lighter than might be supposed. The dentition presents several points of considerable interest. In the Indian species the males alone have greatly developed tusks, while they are well developed in both sexes of the African Elephant. These tusks, or incisor teeth, grow to an enormous size, sometimes reaching the weight of from a hundred and fifty to two hundred pounds.

There are no lower incisors, and only two of the molar teeth are to be seen at each side of the jaw at one time. There are six of these on each side, or twenty-four in all, in the lifetime of the Elephant, and these present a gradual increase in size as they successively appear; they move forward into their working-place in the jaw in regular succession, from behind forwards, each being pushed out by its successor as it gradually becomes worn. The teeth are worn away, not merely by the food on which the Elephant lives, but also by the particles of grit and sand entangled in the roots of the plants torn up for food. The trunk, or proboscis, is really a most wonderful organ. It is formed by the prolongation of the nose and upper lip, and is of a sub-conical shape, consisting of two tubes separated by a septum. At the extremity of the trunk, on the upper side, above the opening of the nostrils, is a lengthened process which functions like a delicate finger; while beneath and opposite to it, and acting, so to speak, as a thumb, is a tubercle. By its aid food and water are carried to the mouth, and when necessary it is used as a syringe for spraying water over the body. The length of the trunk—nearly eight feet in a full-grown animal—does away with the necessity of a long neck, a short and muscular neck being absolutely necessary for the support of the great head and tusks.

The Indian Elephant is found in India, Ceylon, Burmah, Siam, Cochin-China, the Malay Peninsula, and Sumatra. It appears to be more docile, easily tamable, and sagacious than the African species. In captivity it proves an invaluable labourer, its assistance in road-making, bridge-building, ploughing, piling logs, lifting weights, and similar operations being of the utmost service.

The African Elephant, formerly trained for war and pageantry by the Carthaginians, and later by the Romans, is no longer tamed. It may be distinguished from its Indian relative by a number of external features. The ears are very much larger in size, and the head slopes back much more, so that the face does not wear such an intelligent expression as that of the Indian Elephant; the tip of the trunk has a slight triangular projection on both the upper and lower part of the circumference of the aperture; and there are four nails on the front feet and three on the hind. The great molar teeth have considerably fewer ridges, the greatest number for

a single tooth being eleven, while in the Indian Elephant there are as many as twenty-seven.

Thanks to the researches of many eminent geologists, the ancestral history of the Elephant has been established with wonderful precision. In the Natural History Museum at South Kensington may be traced the story of the evolution of the Elephant, step by step, from its somewhat pig-like ancestor, the *Meritherium*—whose fossil remains were discovered by Dr. Andrews, of the British Museum, in the Eocene and Miocene deposits of the great western desert of Egypt. Next comes the *Palæomastodon* of the Egyptian Eocene deposits, a creature about the size of a horse, with a long face, and moderately large downward-pointing tusks in the upper jaw, and then the strange-looking *Tetrabelodon* (*Mastodon angustidens*) of the Miocene deposits of France, which had a long lower jaw terminating in a short pair of tusks, and a short upper jaw with long, slightly downward-curving tusks; then the *Dinotherium*, a mastodon-like creature of the Miocene period of Germany, which had no tusks in the upper jaw, but two huge tusks in the lower jaw, bent downwards, which were probably used for grubbing up roots, etc. The American Mastodon (*Mastodon americanus*), more closely resembling the true elephants, followed, and finally the hairy Mammoth Elephant (*Elephas primigenius*), with its shaggy coat and immense upward- and slightly inward-curved tusks.

The **Hyracoidea** are an interesting group of small mammals, popularly known as "Conies," and having a singular resemblance to rodents on account of their short ears, greatly reduced tail, and habit of sitting in a squatting attitude. The likeness, however, is only skin deep, for they agree with other Ungulates in structure; the toes are united by skin to the nails, just as they are in the elephant and rhinoceros, while the molar teeth are bevelled off in a very similar manner to those of the hippopotamus. The Hyrax is limited in its distribution to Ethiopian Africa and Arabia (including Palestine); and while some live in rocky ground, others frequent trees, utilising holes in the trunks as sleeping places. The *Hyrax Syriacus* is the "Coney" of the Bible, and is found from the coast of the Red Sea northwards through Syria, by Lebanon, and southwards into Arabia and Ethiopia. It is a wary little animal, about the size of a rabbit, clothed with soft brownish fur,

except for a patch of whitish colour on the back in the region of a gland, which seems to spread out and become more noticeable when the little animal is enraged. There are four toes on the front limbs and three on the hind.

The Odd-Toed Ungulates, or **Perissodactyla,** may be grouped in three living families—(1) The *Equidæ*, or Horses (including the asses and zebras); (2) the *Tapiridæ*, or Tapirs; (3) the *Rhinocerotidæ*, or Rhinoceroses.

All the existing and some of the extinct members of the Horse family (*Equidæ*) are characterised by the feet being formed of one perfectly developed digit or toe only, the other toes being present in a rudimentary shape as the splint bones. Thanks to the discovery of abundant and very perfect fossil remains in various strata, it has been possible to trace, step by step, the ancestry and evolution of the modern Horse, from a five-toed ancestor called the Phenacodus that lived during the Eocene period of the earth's geological history. The true Horses are represented by one well-established species, *Equus caballus*, from which all the other races or varieties are descended by a process of selection under the care of man, and these vary in size, proportion of parts, and colour, as much as any two closely allied species of wild animals can be said to be defined from each other. Darwin considered that no aboriginal or truly wild Horse is positively known to exist, for the so-called "Wild Horses" of the East may probably be descended from those which have escaped from the service of man. In all probability the truly wild Horse has been exterminated by the hand of man in those countries which it formerly inhabited, and in which it has left its remains to attest its former presence.

Sir W. Flower in his book on "The Horse" states that he considers that "the nearest approach to truly wild Horses existing at present are the so-called tarpans, which occur in the steppe country north of the Sea of Azov, between the river Dnieper and the Caspian. They are described as being of small size, dun colour, with short mane and rounded obtuse nose." The genus *Equus* includes the Horse, the Asses, and the Zebras.

The different varieties of the Horse are so well known as to call for no special mention here; indeed, to describe them adequately would require more space than the whole of the present volume. Of the Wild Asses, opinions differ regarding the number

of truly distinct species, but there are probably three Asiatic and two African. Of the former, the best known is the Onager (*Equus onager*), which is found in Cutch, the Punjab, and Persia. It is very swift and surefooted, and is of a uniform yellowish sand colour, with a dark stripe along the middle of the back. According to Tegetmeier, instead of its being the absolutely untamable animal some writers would have us suppose, it occasionally "becomes so tame as to be troublesome." The Kiang is confined to the high tablelands of Tibet at an elevation of 15,000 feet and upwards. It is a large animal, measuring about fourteen hands in height, and is exceedingly swift and wary. The African Asses are interesting as approaching to the zebra type in having tracings of stripings. Of the two species, the least known is the Nubian Ass (*Equus africanus*), which is probably the parent of the domestic donkey. It has a stripe down the back, and another across the shoulder; the tail is covered with short hairs, the lower part terminating in a long hairy tuft. Dr. Sclater describes three species of Zebra—(1) the true Zebra, which is black and white, inhabits the hilly districts of southern Africa, and is by far the most conspicuous and handsomest of the Ass tribe; (2) Burchell's Zebra, which is black and yellow, and inhabits the plains of southern Africa; and (3) the Quagga, less attractively coloured, and which is now totally extinct.

Sir Cornwallis Harris gives the following description of the Quagga:—"The geographical range of the quagga does not appear to extend to the northward of the river Vaal. The animal was formerly extremely common within the colony; but, vanishing before the strides of civilisation, is now to be found in very limited numbers and on the borders only. Beyond, on those sultry plains which are completely taken possession of by wild beasts, and may with strict propriety be termed the domains of savage nature, it occurs in interminable herds; and, although never intermixing with its more elegant congeners, it is almost invariably to be found ranging with the white-tailed gnu and with the ostrich, for the society of which bird especially it evinces the most singular predilection. Moving slowly across the profile of the ocean-like horizon, uttering a shrill, barking neigh, of which its name forms a correct imitation, long files of quaggas continually remind the early traveller of a rival caravan on its march. Bands of many

hundreds are thus frequently seen doing their migration from the dreary and desolate plains of some portion of the interior, which has formed their secluded abode, seeking for those more luxuriant pastures where, during the summer months, various herbs thrust forth their leaves and flowers to form a green carpet, spangled with hues the most brilliant and diversified."

In 1864 the last specimen of the Quagga ever exhibited was received by the Zoological Society, and it is thought that the animal may have survived in its wild state in the Orange River Free State until about 1878, when it became extinct. It was a handsome animal, more strongly built than either Burchell's or the true Zebras. The upper parts of the body were dark rufous brown, and the head, neck, mane, and shoulders were striped with dark brown, the stripes gradually fading until lost behind the shoulder. Grevy's Zebra (*Equus grevyi*) differs from the other Zebras in its larger size, in the large head and ears, and in the hairiness of the latter.

With its fat body, short legs, long snout, small eyes, and stumpy tail, the Tapir presents a somewhat pig-like appearance, but it is a deceptive one, for the nearest living allies of the Tapir are not the pigs, but the horse and the rhinoceros. The Tapir is distributed over wide regions in the warmer parts of the Old and New Worlds. All the animals comprised under the single genus *Tapirus* possess short and movable trunks, by which they convey their food into their mouths, and at the extremity of which are placed the nostrils. They inhabit principally the inmost recesses of the dense tropical forests, and are nocturnal in their habits. The genus is divided into three species, namely, (1) the American Tapir (*Tapirus americanus*), Roulin's Tapir (*T. villosus*), and the Asiatic Tapir (*T. malayanus*). Of these the best known is the American Tapir, which is found in almost all parts of South America from the Argentine to Central America, and from the Andes to the Atlantic. This species is characterised by having the general colour throughout of a deep brown. In captivity it soon becomes quite gentle and domesticated, showing considerable affection for its owner. Roulin's Tapir, or the "Hairy Tapir" as it is sometimes called, is mountainous in its habitat, being found on the inner range of the Cordilleras. In the Miocene and Pliocene Ages the Tapir inhabited Europe, and its fossil teeth are met with frequently in the crag deposits of Norfolk and Suffolk.

The Rhinoceroses are to be found at the present day in Africa, south of the Sahara Desert, and in India, Java, and Sumatra, where the climate is tropical or sub-tropical. They are represented by several living species, as well as by several extinct forms which ranged in the late Tertiary times, over nearly the whole of Europe and Northern Asia. The principal characters which are to be observed in the Rhinoceros are the large, unwieldy body, supported on short, stout legs, terminating in a large callous pad with hoof-bearing toes, the large long head, the small eyes and ears, and the short tail. All the living species also possess one or two "horns," which are placed in the middle line of the head on and above the nose. These "horns" are really only appendages of the skin, for they are but skin deep, and are composed of a series of fibres matted together, and similar, if not identical, to a mass of hair in which each hair is confluent with those near it. Horns were present also in all the fossil species excepting one, the *Aceratherium*, the Hornless Rhinoceros of the Miocene Age. The skin is of great thickness in all the species, and is converted into a jointed armour in some of the Asiatic species; except in the Hairy-Eared Rhinoceros, it is covered scantily with hair.

There are three well-differentiated species of Asiatic Rhinoceroses, in all of which the skin is much thrown into folds, and of these the Indian Rhinoceros (*Rhinoceros indicus*) is the largest form, and has enormous folds of skin at the neck and hanging over the limbs, and one large, backward-sloping horn. The Sumatra species has two horns, and a much thicker coat of hairs, and a variety of this species is the Hairy-Eared Rhinoceros (*Rhinoceros lasiotis* of Sclater), from Assam. Only two certainly known species of Rhinoceros are found in Africa—namely, the so-called "White" Rhinoceros (*Rh. simus*) and the "Black" Rhinoceros (*Rh. bicornis*). The origin of the popular names is difficult to comprehend, since the "white" animal is, if anything, darker than the "black." They are, however, easily distinguishable in other ways, for while *Rhinoceros simus* has a square upper lip, and consequently crops the herbage on the ground, the *Rhinoceros bicornis* has a prehensile upper lip which projects beyond the lower, and enables the animal to feed principally upon the leaves and branches of shrubs. Both animals have two horns, and the longest

known horn of the "White" Rhinoceros measures fifty-six and a half inches in length. It is doubtful if the Rhinoceros is as fierce as has been asserted, though it certainly has a hasty temper; its sudden charge is a most extraordinary sight to witness, the great weight and size of the animal giving the impression of an immense and absolutely irresistible moving force. At the same time, it is really a clumsy onrush, for when going full speed ahead the animal cannot make a sudden swerve to right or left, so that provided he keeps his head, and has room for a spring, it is not a difficult matter for the hunter to leap aside and avoid being crushed to death. The poet's advice,

> "If ever you meet a Rhinoceros,
> Do not linger but flee
> Up the very next tree,"

is not altogether sound, for unless the tree be a very stout one, the fugitive would stand a chance of being ignominiously shaken out of its branches. Though somewhat short-sighted, the Rhinoceros has its sense of smell acutely developed, and therefore is a difficult animal to approach

CHAPTER XXVII

THE EVEN-TOED UNGULATES

BESIDES the Odd-toed Ungulates, or *Perrisodactyla*, there is another large group in which the extremities of the fore- and hind-toes are entirely surrounded by horny tissue in the shape of hoofs. These are the Cloven-hoofed or Even-toed Ungulates, forming the **Artiodactyla,** in which the toes are even in number, being four in all the feet, except in the camel tribe, the giraffe, and a very few antelopes, in which only two are present. It is the digit which corresponds to the human thumb in the forefoot, and to the great toe in the hind, which is always deficient, the inner and the outer digits being frequently reduced to minute rudiments, as seen in the ox and the sheep. All are strictly terrestrial animals, none being arboreal in their habits; the hippopotamus is the only member of the group which is aquatic in its habits.

In all the Even-toed Ungulates which carry horns or antlers these are appendages paired and lateral in position, at the same time that they are either supported upon bony cores, or are formed of bone itself, and are situated upon the forehead. These Even-toed Ungulates may be conveniently subdivided under two headings, namely: (1) the Non-Ruminants, including the pigs of the Old World, the peccaries, and hippopotami; and (2) the Ruminants, comprising the camels, llamas, deerlets, oxen, and deer.

The Wild Boar has a wide distribution, being found in Europe, North Africa, and Hindostan. Its body is of a dusky-brown or greyish colour, and the tusks of the male are long and powerful, and project beyond the upper lip. The long head, with its somewhat tapering snout, is set upon a short, thick neck, rising out of a stout, muscular body, which is covered with coarse hairs intermixed with wool. On the neck and shoulders the hairs take

the form of bristles, being long enough to form a kind of mane which the boar erects when enraged. Although by choice herbivorous, feeding on plants, roots, and fruits, the Wild Boar will also devour snakes and lizards, nothing appearing to come amiss to its voracious appetite. Four toes are present on each of the forelegs, the two larger ones being in the middle, and the smaller outside and not reaching the ground. If we were to take away these outer and nearly functionless toes, then the Hog's foot would resemble that of the oxen, deer, and antelopes; for the Hogs are of an ancient race, and these toes are one of the anatomical facts that prove their lineage.

Most grotesquely hideous of the Pig tribe is the Wart Hog (*Pracochœrus africanus* and *æthiopicus*), which has gained its popular name from the various excrescences upon its face, and the wart-like structures on its forelegs. A pair of great protuberances just below but close to the eyes look almost like blunt, stumpy, flesh-covered horns. The tusks are long, curved, and powerful. It is stated that the Wart Hogs, which are confined to Africa, herd together more or less, and live in the deserted burrows made by the African ant-eater or aard-vark; though whether the Wart Hog first evicts the rightful tenant of the mound does not appear to have been ascertained. A very large number of so-called species of the Hog have been described, yet the differences in most cases appear to be so few and unimportant as hardly to warrant the distinction of "species," and "varieties" would be a truer term. Dr. Forsyth Major considers that the number should be reduced to four if not to fewer species.

The Peccaries are confined to the New World, and are the representatives of the Hog family in those regions. Though small—being about three feet long and about fifty or sixty pounds in weight—they are formidable animals, for they know no fear and will attack anything which comes in their way, inflicting serious wounds with their short and very sharp tusks, which are concealed within their lips. They live in herds, and are nocturnal in their habits. They differ from the Pigs of the Old World in several important characters; the hind-feet have only three toes, the stomach is more complex in form, and the number of teeth in the jaws is reduced, as is also their shape, the grinders presenting transverse ridges. Two species are known, the Common Tajuca,

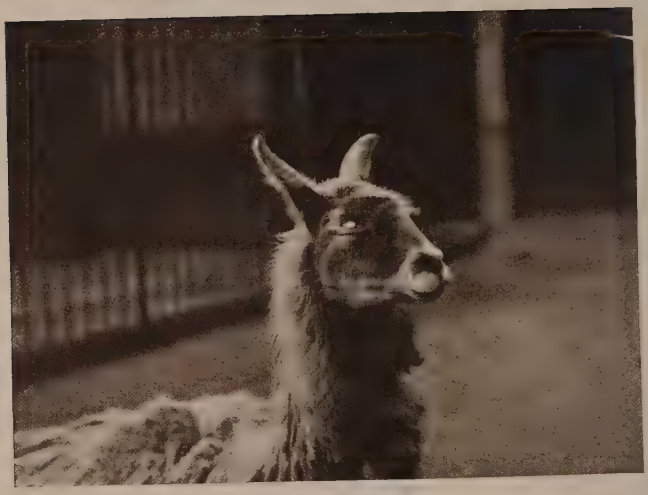
or Collared Peccary (*Dicotylis torquatus*), and the White-lipped Peccary (*D. labiatus*); the first ranges from Texas to the Straits of Magellan, and the latter, which is also the larger and fiercer animal, inhabits the forests of South America. Fossil remains of the Hog family have been found in formations as far back as the Miocene Age, in which period the canines were not developed into large tusks.

To-day the great Hippopotamus (*Hippopotamus amphibius*) is confined in its range to the African continent, though from remains that have been found it appears to have recently inhabited Madagascar; while its fossil remains (a small species not much larger than a domestic pig) have been found in the island of Cyprus in Asia, Europe, and even the Thames gravels. It is a gigantic, thick-skinned animal, attaining a length of at least fourteen feet, and has but few hairs upon its corpulent body. The legs and tail are short, and there are four toes on each foot. The animal at times, especially after just quitting the water, produces a remarkable secretion, or "bloody sweat," which has, of course, nothing to do with the blood, and contains small crystals and corpuscles from the skin. The nostrils are on the surface of the head, and can be closed when the animal is under water. Not only can the Hippopotamus swim, but it can walk rapidly along the bottom of a river. It is occasionally known to swim out to sea from the mouths of the rivers which it frequents, and it is thought that it was in this way that the Hippopotamus reached Madagascar; while Europe and Asia were, of course, in past geological ages, connected by land with Africa. The front part of the head is broad and massive, the eyes are prominent and placed far back and well towards the upper surface, and the ears are very short and have a special arrangement of muscles by which they can be closed when the animal dives beneath the surface.

The Hippopotamus is nocturnal in its habits, frequenting rivers and lagoons, and rarely leaving them or their immediate vicinity, except at night, when it may ravage the green crops of the native villages. Its food consists of grass, young shrubs, and water plants, and it is also said to be particularly fond of green corn. Its mouth is very large, and armed with grinders and tusks which present a most formidable appearance when the animal opens its mouth, for it has a gape which is unsurpassed in width by that of any

Rhinoceros

Tapir



Head of Llama

Llamas

other creature. The tusks are enormous, particularly those in the lower jaw, which are curved upwards.

The true Swine, the Peccaries, and Hippopotami form but a small division of the Cloven-hoofed or Even-toed Ungulates, by far the greater number being included in a group familiarly known as the **Ruminata,** because, as part of the digestive process, they 'chew the cud." To quote Professor A. H. Garrod: "As to the details of the process, the individual, a cow, for instance, whilst grazing, nips off the grass between the large cutting teeth in the front of the lower jaw and the tough pad which replaces in these creatures the similarly-situated teeth of the upper jaw. After each mouthful it does not proceed to masticate the food, but swallows it forthwith, and continues thus to graze until it has satisfied its appetite. Seeking a quiet and shaded spot, it then seats itself that it may ruminate, or chew the cud, at leisure. If watched, it will be seen that it commences shortly to perform a slight hiccough action, in which some contraction of the flanks is to be noticed. Its mouth, which was previously empty, is found to be full of what it is not difficult to recognise to be coarsely-masticated grass, which has been forced up into it; and this it immediately proceeds to chew between its back or grinding teeth, in a slow and continuous manner, moving its lower jaw uniformly from one side to the other. When this chewing process has lasted for a time sufficient to convert the food into a pulpy state, it is again swallowed, after which another bolus is brought up to undergo a similar operation. And this is repeated at frequent intervals until most of the food swallowed has been masticated." A complicated stomach is necessary for the production of this elaborate chewing process, and this organ, as found in the ox, is divided into four well-defined chambers or compartments, viz.: (1) the *rumen*, or paunch; (2) the *reticulum*, or honeycomb bag (so called from the peculiar arrangement of the ridges on the mucous membrane which lines it); (3) the *psalterium*, or *manyplies*;[1] and (4) the *abomasum*, or reed, which is the stomach proper.

The Chevrotains (*Tragulina*), or Deerlets, are undoubtedly the most ancient of the Ruminata, and stand as a connecting-link between the swine and the true ruminants. They are all

[1] So called on account of the longitudinal folds, like the leaves of a book, with which the lining membrane is raised.

particularly delicate, diminutive, graceful animals, the slenderness and clear-cut outline of their limbs being particularly striking. The absence of antlers in both sexes, their elegantly pointed noses, and large dark eyes give these animals a very characteristic appearance. The bones of the feet show that these Deerlets cannot be correctly classed with the more ordinary ruminants, but that they approach more closely to the swine. To quote again Professor Garrod: "Each foot of the common pig possesses four toes, that corresponding to our thumb in the fore-limb, and to our great toe in the hind, being absent. The bones of all these toes are quite separate from one another, as in those of man, at the same time that those of the outer and inner digits in each limb are smaller than those which bear the larger hoofs. In the true ruminants and in the camel tribe these larger toes are partly fused together, the bones of digit three and digit four corresponding to those situated in the human palm and sole, being joined from end to end to form the 'cannon-bone'; whilst those of digit two and digit five are reduced to mere imperfect splinters, or are sometimes altogether lost, as in the giraffe and in the camel. Now, in the Deerlets, these bones are not blended at all in the fore limbs of the Water Deerlet of West Africa, in which, as in all the other species, digit two and digit five are perfect from end to end. They therefore stand, in this respect as in others, easily explained, intermediate between the swine and the true ruminants."

The Deerlets are Oriental and West African in their range, being found in India, Ceylon, Malacca, Java, Sumatra, Sierra Leone, and the Gambia. Their bodies are about the size of that of a hare or rabbit, and the legs are long and extraordinarily slender.

The Camels, together with the Llamas, form the tribe *Tylopoda*, a name which is derived from the Greek, and signifies that the feet are not protected by hoofs, but are covered with a hardened skin enclosing the cushion-like soles of the feet, which are so constructed that they spread out when brought in contact with the ground—an arrangement of decided advantage to desert-frequenting animals. The Camels of the Old World are divided into two quite distinct species, the Bactrian Camel (*Camelus bactrianus*), with two humps, and the Dromedary (*C. dromedarius*),

with only one. The Camels of the New World are represented by the genus *Lama*, and differ from their allies of the Old World by their smaller size, absence of hump, and disappearance of one premolar.

Although called by a variety of names—Llama, Alpaca, Huanaco (sometimes written Guanaco), Vicuña—Mr. Oldfield Thomas considers that there are really only two species, namely the Huanaco (*Lama huanacos*), of which there are two domestic breeds, the Llama and Alpaca; and (2) the Vicuña (*Lama vicugna*); both species being South American in range.

The stomach of the Camel is of interest in showing how an organ may become modified to the environment of its possessor, for in the walls of the paunch there are present two extensive collections of "water cells," capable in the Dromedary of storing a gallon and a half of water, which serve their owners in good stead whilst traversing the desert, or residing in regions where fresh water is not easily procured. The appearance of both the Dromedary and the Bactrian Camel is too familiar to call for further description. They are singularly disagreeable, spiteful, stubborn animals, displaying little or no affection for or interest in their owners. The Llamas have the same evil temper, and, in addition, the abominable habit of spitting—not only saliva, but part of the contents of the stomach being forcibly ejected—while they kick and bite as viciously as their Old World relations.

Stay-at-home sentimentalists often wax eloquent upon the noble and patient "Ship of the Desert," as they are pleased to term the Camel, but their misplaced admiration would receive a rude awakening and would very quickly evaporate if they ever had to deal with him upon his "native heath," or have to help with or supervise the loading of precious camp baggage upon his anything but willing back.

The Deer tribe, known scientifically as the *Cervidæ*, are absolutely distinguished from all other ruminant animals by the existence of antlers, which are, with but few exceptions, invariably present in the male sex. The females do not carry antlers, except in the case of the Reindeer, in which, though present and similar in shape, they are much smaller in size.

"The nature, growth, and shedding of the antlers deserve special consideration. In the commencement of the spring a pair

of knobs are to be seen upon the forehead of the adult male animal. These are covered with a nearly smooth dark skin; and a scar can be detected in the middle of each, which is that left by the antler of the year before, where it fell off. As the weather becomes more propitious, these knobs commence to grow, feel warm to the touch, and are evidently filled with actively circulating blood supplied by special vessels which are developed at the time. They do not increase regularly in all directions, for if they did the antler would be a sphere, but they sprout out, as it may be termed, around the above-mentioned scar; in most cases there being one branch which takes a direction forward, whilst a second larger one makes its way backward. These become, in the fully-formed antler, the brow antler and the main beam; and it is by other branches growing upon the beam, according to definite laws, different in different species, that the elaborate complications of the fully-developed structure are produced. As long as the antler, which is composed of genuine bone of very dense texture, is increasing in size, it will be found to be covered with the same warm black skin as is the knob from which it sprang; and as this skin is covered with short, fine, close-set hair, it has received the name of 'velvet.' It is this 'velvet' which secretes the bony texture of the antler from its inner surface, just in the same way that the outer covering (the periosteum) of any long bone of the body is mainly concerned in the formation of the bone itself. As, also, in the same way, if we seriously graze our shins, and scrape off this covering, the bone exposed is very apt to die, so, in the Deer any mishap to the 'velvet' injures the growth of the antler in the part affected. The animals, therefore, during the time they are 'in velvet' are more than usually careful to protect their cranial appendages, and are inoffensive even to strangers. When their antler-growth has ceased, their natures change. The 'velvet' has performed its function and dries into a parchment-like membrane, to get rid of which the Deer adopt a very simple method. They rub their antlers against any neighbouring trees, and force them into the soft earth, until there is none left, and the bare bone, with scarcely any trace of hollow in the middle of it, is completely exposed. Now, in the glory of their full equipment, they go in search of others of their kind, having previously maintained a comparative solitude. They try their strength by butting at imaginary enemies, and choose

their wives, unless prevented by others of their species mightier than themselves, with whom, if fairly matched, they enter into the most formidable contests, to win or be driven from the herd with ignominy."[1]

The Red Deer is a native of the British Isles and many parts of Europe, and is still to be found wild in Exmoor Forest, north of the Forth and Clyde in Scotland, and about Killarney, Connemara, and Erris in Ireland. The pairing season is in the early part of October, and the calves are born about the end of the following May or early June; while the stags drop their antlers between the end of February and the earlier part of April.

The Wapiti Deer resembles the Red in almost every detail, except that it is a larger animal. It is a native of the woodlands and mountains of North America, and specimens brought over to England are kept in confinement without difficulty, fine examples generally being on view in the Zoological Gardens in London.

The True Elk, or Moose Deer, is the largest of the *Cervidæ*, and is found in North America, Northern Europe, and the coldest parts of Asia. When adult it may attain to the great height of eight feet at the shoulder, and, with the huge palmated antlers, is a truly magnificent animal.

The Sambur, or Gerow (*Rusa aristotelis*), of the hilly districts of India, is a noble Deer, reaching nearly five feet in height, and of a deep brown colour. It is stoutly built, and its massive antlers, which present three powerful points, reach over three feet in length. Shy and wary, it frequents stony hills where there is plenty of cover and easy access to water, requiring all the skill of the experienced hunter to successfully come up with it.

The Muntjacs form a group of small and elegant Deer found in India, Burmah, China, the Malay Peninsula, and the larger islands of the Indo-Malay Archipelago. They differ from all other members of the family, in that their diminutive antlers are supported on lengthy bony pedestals covered with a hairy skin much like the horn-growths of the giraffe. Most, also, have a pair of elongated ridges between the eyes, within the folds of which small glands are situated, at the same time that there is a dark crest of retroverted hair, tending to the shape of a horseshoe, upon the forehead. In the males the upper canine teeth develop into

[1] Prof. A. H. Garrod, F.R.S.

tusks, which project externally some way below the lip, though not so far as in the musk, forming efficient instruments of attack.

The Reindeer, which differs from all its allies in that the females carry antlers as well as the males, is found distributed throughout the Arctic regions of Europe, Asia, and America. In Spitzbergen, Finland, and Lapland it attains the greatest size, being inferior in stature and strength in Norway and Sweden. In the New World it is known as the Cariboo, and extends through Greenland, Canada, and Newfoundland. The Reindeer is a powerfully-built animal, with short limbs and a hairy neck, the feet being specially adapted so that the hoofs spread out when pressed upon the ground, and thus increase the surface for support upon yielding snow, which forms the most frequent foothold. The antlers are remarkably large and well developed, while the fur consists of an outer covering of longer harsh, brittle hair, and an undercoat of close, finer and wool-like texture.

We have seen that in the *Cervidæ*, or Deer Tribe, the horns, or antlers, are cast off each year, and soon replaced by others, which, in turn, share the fate of their predecessors ; and that these antlers are entirely made of bone, and when fully grown are not covered with any less dense investment. We have now to consider another group of horned ruminants, which, from the fact that the Oxen are included with them, are called the *Bovidæ*, or Hollow-Horned Ruminants. The males of this group are characterised by the possession of *permanent* bone-cores on the forehead ; these are covered with a dark horny coating, which is not shed during the whole life of their owners (with the exception of the North American Pronghorn Antelope, whose hollow horns are shed from their supporting bony cores annually), and in which, as the horns continue to grow until adult life at least, the tips are the oldest parts. The females in some species have horns like their mates, but smaller, as in the Ox and the Eland ; while in others the males alone are horned. The group includes the Oxen, Sheep, Goats, Bush-bucks, Antelopes, Koodoos ; while the Musk and Giraffes hold a somewhat isolated position.

The Musk Deer (*Moschus moschiferus*) is more nearly related to the true Deer than to any other ruminants, and was considered by Sir W. Flower to be " an undeveloped deer—an animal which in most points (absence of horns, smooth brain, retention of gall-

Young Bactrian Camel

Dromedary

Head of Giraffe, showing long tongue

Studies to show positions of Giraffe when picking an object off the ground

bladder, etc.) has ceased to progress with the rest of the group, while in some few (musk gland, mobile feet) it has taken a special line of advance of its own." This interesting animal has gained its popular name of the Musk from a gland on the surface of the abdomen of the male, about the size of a hen's egg. The whole gland, or " pod," is cut out and sold in this condition to the scent manufacturers. The odour from the freshly-extracted gland is said to be so overpowering that the hunters are obliged to cover the nose and mouth with linen when removing it from the body of the animal. The Musk is about three feet in height ; the ears are large, and the mouth provided with enormous canine tusks which are used for digging up roots. The hoofs are small, but their spread is large because of the yielding attachment of the false hoofs, as in the reindeer. The coat, of coarse and brittle hair, is grey and slightly brindled. The animal is a native of Central Asia, from the Himalaya Mountains to Pekin.

The Giraffe is another aberrant member of the group, presenting peculiarities in its organisation which separate it from the deer on the one hand, and the Hollow-Horned Ruminants on the other. In both these groups the appendages on the head, whether developed as antlers or as horns, are distinct prolongations from the forehead bones themselves. In the Giraffe, however, the three bony appendages, one median and two lateral, all covered with skin, instead of being produced as outgrowths from any portion of the skull, are separate and independent conical, bony " processes," which stand upon the skull, capping roughened conical prominences destined to support them.[1] They are present in the female as well as in the male, and well developed even in the newly-born calf. The neck, which on account of its great length is such a striking and characteristic feature, nevertheless consists only of the normal seven vertebræ which go to form the neck of a mammalian animal. Limited in range to the African continent, there are two distinct species of Giraffe, one found in Somaliland, and the other in South Africa. The word Giraffe means in Arabic, literally, " one who walks swiftly." While the inordinate length of neck is generally supposed to have some relation to the animal browsing off the foliage of trees, a more ingenious explanation refers to its value as a watch tower, enabling the Giraffe to keep

[1] Prof. Garrod, F.R.S

a wide outlook over the tall grass of the districts it frequents and which gives shelter to innumerable lions and leopards, which are its natural foes. In confirmation of this theory, it is noteworthy that the longest-necked bird, the ostrich, lives under similar conditions of environment.

The Okapi (*Ocapia johnstoni*), recently discovered by Sir Harry Johnston, inhabits the densest portions of the forests of the northern and eastern parts of the Belgian Congo, and is about the size of a large mule. It stands high at the shoulder, though not to such a degree as its cousin the giraffe, while the neck is also long in proportion to the body. The animal presents a very striking appearance, its neck and body ranging from a bluish black to a deep vinous brown, while the legs are more or less cream-coloured, barred with longitudinal black stripes and patches, the face being a greyish-white colour, and the hind-quarters marked with orange-fringed white stripes. The horns consist of short pedicles of bone, and exist only in the adult male. No living specimen has as yet reached Europe, but complete skins and heads have been obtained, and are now to be seen in the Natural History Museum at South Kensington. The Okapi is said to be an extremely shy animal, and lives in pairs in the deepest parts of the forests.

The Gnu and the Brindled Gnu are two most singularly grotesque-looking creatures. The head is not unlike that of a small Cape buffalo, while the limbs and hind-quarters somewhat resemble in their proportions and size those of a pony. The nose is broad and flattened, and the horns are broad at their base and turn upward in a hook-like manner. The Gnu is a native of South Africa, and from all accounts is an extremely wild, fearless animal. Its speed is great, and when alarmed it has a habit of prancing about and kicking out furiously in all directions.

The Klipspringer, the Ourebi, the Steinbok, and the Grysbok form a small section of the Antelopes, in which the males alone possess horns. They are all African in their range, and remarkably graceful, agile animals. The Klipspringer stands a little under two feet high; it is the heaviest in build of the four; its horns are four inches long, and curved a little forwards, and it lives singly or in pairs, in mountainous districts. The Waterbucks and Reedbucks of Africa are so called on

account of their water-loving propensities. The horns are long, and present in the male alone. "The Water Antelope," writes Drummond, "is an extremely fine animal. The large-sized horns which, in the male, crown its brow, bear a strong resemblance to those of the Reedbuck, while the habits and general appearance of both species are almost identical. Both frequent thickets and reedy places near water, and are principally found in pairs or small groups."

The Eland attains to the size of an ox, the bull standing six feet and a half at the withers. Two varieties are known, one of a pale fawn colour from Central Africa, the other, from South Africa, of a bright yellow tan colour, marked transversely with narrow white lines, about fifteen in number, running from a black line, which goes along the back, to the belly. The full-grown bull has a broad tuft of lengthy, slightly brown hair on the forehead, between and in front of the horns, which are straight and long, and at their bases carry a thick and conspicuous screw-like ridge which extends in some cases nearly to their ends. The female is smaller, slighter of build, and with less ponderous horns.

Under the title of Gazelles are included several strikingly elegant, small, slender, sandy-coloured species of ruminating animals, in which the males always, and the females in most cases, carry horns, which are transversely ringed, and vary considerably in the direction which they take; many are curved in such a way that the two together form a lyre-shaped figure, others are nearly straight, turned slightly backwards or forwards, and dividing or converging at the tips. When present, the horns of the females are more slender than in the corresponding males. The Gazelles inhabit Africa, Arabia, Persia, India, and Central Asia only. They rarely exceed thirty inches in height at the shoulder; the largest, the Swift Antelope of Pennant (*Gazella mohr*), reaching nearly three feet. In all the Gazelles the face is marked with a white band running from the outer side of the base of each horn nearly down to the upper end of each nostril, cutting off a dark triangular central patch, and bordered externally by a diffused dark line. The under surface of the abdomen is white, and there is a dark line traversing the flank which bounds this. Some twenty species of Gazelles are known.[1]

[1] Prof. A. H. Garrod, F.R.S.

Between the bearded Goat and the beardless Sheep there exist intermediate species, which so completely fill up the gaps that it is almost impossible to separate the two into different genera. In the Goats the horns are flattened from side to side, and rough in front and arched backwards, whilst in the Sheep they are more uniformly cylindrical, turned laterally, curling downwards, and often corkscrewed.

The Markhoor, or "Serpent Eater," of North-East India and Cashmere, is a fine goat of larger size than the Ibex, with immense, much flattened, triangular horns. The general colour of the body is a dirty, light-bluish grey, the long beard being of a slightly darker tint. It is a shy and active animal, inhabiting the most precipitous and dangerous parts of mountain regions, and leaping from rock to rock with the greatest ease and agility.

The Goats of Cashmere are famous on account of their long and very fine wool, which is employed in the manufacture of cashmere shawls. The Ibex is found in the Alpine heights of Europe and Western Asia, including the Himalayas; and the Paseng is the Wild Goat of Western Asia.

The Wild Barbary Sheep is a large and handsome species, with a comparatively long, tufted tail. The horns are well developed, though not of massive build. The hair on the chin is short, whilst that along the lower margin of the neck, as well as on the front of the knees, attains a great length. The American Big-Horn, or Rocky Mountain Sheep, have the horns in the form of a complete circle in the male, and they are said to come so far forwards and downwards that old rams find it impossible to feed on level ground. The Moufflon at one time abounded in Spain, but is now restricted to the islands of Corsica and Sardinia; its horns are not very large, and curve backwards, and then inwards at the tips. It frequents the summits of the precipitous hills in small herds headed by an old ram.

Of the Wild Ox that once roamed the woods and forests of Britain, small herds exist in a semi-domestic state in the parks of Chillingham and Cadzow, while specimens are to be seen in the Zoological Gardens in London, where they breed regularly. They are handsome animals with creamy white hides, red ears, black muzzle, and well-developed horns. The Chillingham cattle still

retain many wild traits, feeding at night or in the evening, calving in the security of the woods, etc.

The Zebu, or Brahmin Bull, is a native of India, and has short horns, large drooping ears, and a high hump upon the back, as well as an ample dewlap falling in undulating folds along the whole length of the neck. It varies greatly in size, some individuals being no bigger than an average month-old calf, and is of a gentle, mild disposition. These Bulls, which are consecrated to Siva, are objects of the greatest veneration to the pious Hindoos, who permit them to help themselves to the contents of the fruiterers' stalls, and if they select the middle of some narrow street in which to lie down and doze, are left undisturbed, all traffic being held up or diverted until the sacred animal chooses to arise and go on its way.

The Gour, the Gayal, and the Banting are three species of wild cattle found in the Oriental world, from India to Java, peculiar in possessing a ridge running along the middle of the back, and horns, which, after running outwards from the head, are directed upwards and not backwards. Of these the Gour of Central India is the largest. Its colour is a glossy deep-brown or black, excepting a ring of white encircling the base of each hoof, and a white tuft on the forehead. The horns are about two feet in length, strong and curved boldly upwards. The Gayal carries its nose forwards, as a rule, like a buffalo. Its ears are long, and it possesses a smaller dewlap than the zebu. Its general colour is a varying and generally dark brown, the abdomen and legs being white in parts; the horns are conical, turned directly outwards, and a little upwards at their tips and do not exceed a foot and a half in length.

Closely related to the oxen are the Bisons of Europe and of North America, together with the Tibetan Yak. The two species of Bison agree closely with one another in general appearance, the American form being shorter and weaker in the hind-quarters, and a little smaller altogether. The hair of the head and neck is very abundant and long, forming a mane of very dark colour, at the same time that it nearly conceals the eyes and ears as well as the base of the short conical horns, which are diverted outwards and upwards. Under the chin there is a lengthy beard, and a line of long hair extends along the back nearly to the tail, which is terminated by a lengthy tuft. There is a hump

developed on the shoulders. The European Bison, or Auroch, is on the verge of extinction, while of the vast herds of the American Bison, or Buffalo, as it is popularly called, that roamed the great plains, only a few small herds, jealously guarded in parks and reservations, remain.

The Yak differs from the bisons mostly in the distribution of its long hair, which, instead of being situated on its hump and neck, forms a lengthy fringe along the shoulders, flanks and thighs, and completely invests the tail. It is a native of the high ground of Tibet, where it is strictly preserved by the native Government. In colour it is black, except for some spots upon the face, which are grey or white. Captain Kinloch, writing of the animal, states that "the Yak inhabits the wildest and most desolate mountains; it delights in extreme cold; and is found, as a rule, at a greater elevation than any other animal. Although so large a beast, it thrives upon the coarsest pasturage, and its usual food consists of a rough, wiry grass, which grows in all the higher valleys of Tibet up to an elevation of nearly 20,000 feet."

The Buffaloes have the horns flattened and triangular in section, inclined outwards and backwards, turning up at the tips. The Common Buffalo is found in Southern Europe, North Africa, and the Indian region. The huge Indian variety, with most lengthy horns, is also known as the Arnee. Its horns are elongated and narrow, sometimes reaching six feet and a half in length. It lives in small herds, and the bulls are very fierce. The Cape Buffalo has shorter horns, expanded at the base. It is found all over Central and South Africa, and is a most formidable and courageous animal

CHAPTER XXVIII

THE CARNIVORA

THE **Carnivora,** or flesh-eating Mammals, are divided into two great groups, or sub-orders—(1) the *Fissipedia*, or "split-feet," so-called from the fact that the feet are divided into well-marked toes, and comprising the terrestrial Carnivora; and (2) the *Pinnipedia*, or "fin-feet," so-called from the fact that the toes are bound together by skin, forming fins or flippers rather than feet, and comprising the aquatic Carnivora.[1]

The three families of the **Pinnipedia** comprise the Walrus, the so-called Sea-Lions and Sea-Bears, more distinctively known as Eared Seals, and the ordinary or Earless Seals. Their remarkable adaptation to a purely aquatic life, coupled with the fact that the present rapid diminution in their numbers points to an early period for their total extinction, makes them a most interesting group of animals. Sufficiently different among themselves in general aspects and habits as to be recognised at a glance, the three families, nevertheless, have characteristic features common to all, wherefrom the sub-order has received its name. Their toes are united nearly throughout by a web or membrane, as in a duck's foot, which converts the paws into broad, fin-like organs (the flippers), well adapted for swimming purposes. The body is long, usually ample and fleshy in the neck and shoulders, but narrows taperingly behind towards the rump. The head is either flattish and elongated, or more or less rounded, but in all cases relatively small to the bulk of the animal.

The present range of the Walrus is a narrow belt girding Labrador, Hudson's and Baffin's Bays, and skirting the East Greenland coast towards Spitzbergen and Nova Zembla, on to Behring Strait and the islands of Alaska. Thinned by its

[1] The following account of the Carnivora has been chiefly compiled from the writings of Dr. Murie and Professors W. K. and T. J. Parker.

hereditary enemy, the polar bear, on the land side, and stricken down wholesale by man seawards, the day of its extermination seems not far distant. The living Walrus, indeed, presents to us a solitary example of a family once more numerous and widespread, and doubtless coincident with a period when the climate was different from that now existing where their fossil remains have been discovered. In the deposits of Virginia in America, in our Suffolk crag, and in contemporaneous beds in the neighbourhood of Antwerp, bones of Walruses allied to the present northern form have been dug up; while the remains of genera of larger size have also been discovered. The Walrus of the present day grows to a considerable size, Elliott estimating the gross weight of an ordinary full-grown male at 2,000 lbs., while he mentions a specimen shot in the Behring Sea as measuring nearly thirteen feet in length, with a girth of fourteen feet. The unusually flattened head seems disproportionately small to the great neck and sack-like body, though the small, fierce, bloodshot eyes and formidable tusks give it a ferocious appearance.

On land the movements of these animals are very awkward. With high-set shoulders and low hind-quarters, and squat limbs to their heavy body, the forefeet are successively thrust flat forwards from the wrist, each followed by a hitch and swing of the hind foot, as from a pivot on the heel, ending in a sudden jerk. Thus they straddle along in a clumsy way over the rough ice; but in the water their movements are wonderfully swift, easy, and graceful. Though so forbidding of feature, the Walrus is in reality quiet and inoffensive, unless attacked or roused in love-time, when the male can be a very awkward customer to deal with at close quarters. The tusks, which are such a characteristic feature, vary from eight inches to two feet in length, and may weigh from five to fifteen pounds. These teeth continuously grow, and as they wear away their interior becomes filled with tooth bone. They are not used only as weapons of defence, but for raising the body out of the water on to the ice-floe and, more important still, for procuring food. The Walrus frequents banks and shoals where lie buried in the mud an abundance of molluscs, and these are dug up by the aid of the tusks and eagerly devoured. Other marine invertebrates are also eaten, and the Walrus is said to have a liking for dead whale. The females show the greatest

devotion to their offspring, and will expose themselves fearlessly and defend their progeny to the death.

The family *Otariidæ*, or Eared Seals, are distinguished by the possession of a small scroll-like external ear, an appendage absent in the seals generally. It is usual to speak of "Hair" Seals and "Fur" Seals, the latter being the species producing the "sealskin" of commerce. In the Fur Seals there is a dense, soft under-fur, which is lacking in the Hair Seals. The Northern Fur Seal (*Otaria ursina*) is the "Seal" of commerce, and its habits are probably more accurately known than those of any other of the Eared Seals. The males, when full grown, are between six and seven feet long, the females rarely exceeding four and a half feet in length. The male attains its full size about the sixth year, but begins to breed at the fourth; and the females bear their first young when three years of age.

In the spring of the year the adult males first arrive at the breeding ground, or "rookery," as it is termed, and take up their position, each animal taking possession of a piece of ground about ten feet square, desperate fights occurring in its capture; and this warfare proceeds incessantly, for those next the water have to resist all comers or be themselves forced farther inland. Meantime, from the beginning until almost the end of June, the pregnant females make their appearance, at first in small numbers, until the great mass arrive at the close of the month. Each male retains his position as best he can, whilst some of the females hesitate to land, calling out as if in search of some particular mate. The males coaxingly strive to inveigle them ashore, and no sooner do the females approach than they are laid hold of, and a general fight among the whole "rookery" ensues. The quiet, unoffending, small-sized females have a very rough time of it, getting trampled on, bitten, and dashed about in the general excitement, and striving for their possession. In the end, the strongest and most powerful males may secure twelve or fifteen partners, but to retain these wives is a serious business, necessitating strict watch and ward practically night and day, for should the master of the harem dare to doze for a few moments, his more wide-awake neighbour in the rear will take advantage to obtain by foul means what he cannot by fair. Finally, most of the males succeed in obtaining a few partners, the lucky ones in front securing

and holding the greatest number, while those behind must rest content with half a dozen or thereabouts. Then matters settle down more quietly, and in a few days each female gives birth to a single little one. The cubs gorge themselves heartily with the rich creamy milk of their patient mothers, and thrive and grow rapidly. Then comes the business of teaching the youngsters to swim, for they do not of their own account take at once to the water. But they soon learn, frolicking about together in the sea, dashing through the breakers, and "hauling up" on the shore to rest.

But for timely Government intervention, which has secured a strict close time, and limited the number to be killed in certain regions, these handsome and interesting animals would have become exterminated, and it must be a matter of regret to all animal-lovers that, despite existing regulations, the number of Fur Seals steadily diminishes, while the slaughter and skinning of these comparatively defenceless animals is attended by the most revolting cruelties, *the wretched animals, more often than not, being skinned while still half alive.* To quote from Captain Borchgrevink's account, "Specially cruel is the task when seal-pikes are used. Only rarely does an animal die from one or two blows of a pike, and if it is not dead it is considered 'all the better,' for it is easier to skin a seal while it is half alive. In the utmost agony the wretched beast draws its muscles away from the sharp steel which tears away its skin, and thus assists in parting with its own coat. The crash of the skull, the flow of blood, the sobs of the dying, and the brutality of the heartless and careless men are awful." Obtained at the cost of such unspeakable agony to a harmless and defenceless animal, the possession of a beautiful sealskin garment is no matter for pride or jealousy, but rather for loathing and disgust. There are some ten well-marked species of sea-lions, whereof five belong to the "Fur" Seals, and five to the "Hair" Seals. Already some of the former have through their wholesale slaughter become exceedingly rare, or practically extinct.

The true Seals (*Phocidæ*) have no external ears, and the hind limbs are useless for locomotion on land, being bound up with the tail so as to form functionally merely part of that organ. The Seal is not only marine, but is found in the Caspian and Lake Baikal, its presence in those inland seas being considered a vestige of a former connection with the open sea.

The Common Seal (*Phoca vitulina*) is of a yellowish-grey colour, spotted above with black and brown so as to give a mottled appearance, while below it is of a whitish or silvery grey. In length it varies from three to six feet. The roundish head has a short muzzle, prominent whiskers, and large expressive eyes. Docile, intelligent, and quiet in disposition, the Seal can, however, when attacked, take its own part. It has a fairly wide range, being found in the Black Sea, the Mediterranean, the seaboard facing the Atlantic from Spain to Spitzbergen, from Florida along the American coast to Greenland, near Iceland, and around the British and Scandinavian coasts, and the Baltic.

Other Seals which can only be mentioned by name, and do not differ greatly from the Common Seal in habit, are the Greenland Seal, known also as the "Saddleback" or "Harp" Seal on account of two broad semicircular markings on the shoulders, extending nearly to the root of the tail; the Crested Seal, which has a remarkable protuberance upon the top of its head that is really a hood-like development of the nostrils and can be inflated at pleasure; and the Elephant Seal, which also has a remarkably developed nose, though when alive this proboscis is not extended to the degree shown in the heads of many stuffed museum specimens.

The terrestrial Carnivora, or **Fissipedia** (split-feet), may be divided into three sections, represented familiarly by the Bears (*Arctoidea*, or bear-like animals), the Dogs (*Cynoidea*, or dog-like animals), and the Cats (*Æluroidea*, or cat-like animals).

The **Arctoidea,** or bear-like animals, which are nearest the aberrant *Pinnipedia* (seals and walruses), include the sea otter, otter, skunk, sand-bear, badger, ratel, grison, marten, sable, stoat, glutton, racoon, kinkajou, panda, and bear.

The **Cynoidea** include numerous forms, represented by the dog and the fox.

The **Æluroidea,** the most specialised Carnivores, include the cat, lion, tiger, jaguar, cheetah, civet, ichneumon, aard-wolf, and hyena.

All are large, or comparatively large animals, and, as living specimens are generally to be seen in zoological gardens, their appearance is more or less familiar to the general public, so that a lengthy description here is hardly necessary. Therefore, in the

following brief outline, attention will be drawn chiefly to certain characteristics typical of each section.

The most thoroughly aquatic of the *Fissipedia* are the Otters, animals which, although quite capable of active and unembarrassed movement on land, are yet perfectly at home only in the water. In accordance with this mode of life, the toes are webbed and provided with very short claws, and the tail is long, tapering, and flattened so as to serve the precise purpose of the corresponding appendage in a fish. The length of the head and body is about two feet, that of the tail one foot five inches. The fur is a soft brown colour, becoming lighter on the under side of the throat. The skull is greatly elongated, and flattened from above downwards; the facial part of it is small as compared with the brain-containing or cranial part. The region of the skull between the eyes is very narrow, and its floor is wide and thin. In all these points, save the first mentioned, the skull of the Otter approaches that of the Seal.

The Sea Otter differs in many important respects from the Common Otter, and in all such points shows an approximation to the structure of the seals. It is a large animal, about three feet long, not counting the tail, which is about a foot more. Its fur is dark brown, both on the upper and lower surfaces, and presents a frosted appearance, owing to the fact that the long, stiff hairs, which differ greatly from those of the under-fur, are grey or colourless at the tip. The head is very short, the snout naked, the eyes extremely small and placed low down on the sides of the head, and the whiskers are short, but stout and stiff, and mostly directed downwards; altogether, there is something very seal-like about the face. The fore-limbs and feet are small, the paws rather cat-like in their rounded form, and the claws are quite hidden by the hair. The hind feet, on the other hand, are flat and expanded, being no less than six inches long by four broad, and webbed like a duck's feet or a seal's flippers; they differ, however, from the seals in the fact that the toes increase in length from the inner to the outer side. The Sea Otter is found in the North Pacific, chiefly in the regions of Kamtschatka and Alaska, and extends as far south as California. Owing to the value of the fur the unfortunate animal is persistently hunted, and there is every possibility of the species shortly becoming totally extinct.

The Skunk is a stoutly built animal with short legs, a long conical head with truncated snout, and a long bushy tail. The general appearance of the animal is decidedly badger-like, and it occurs throughout the whole of the temperate portion of North America. From glands at the root of the tail the animal can eject to a considerable distance—twelve or fourteen feet, it is stated—a most horrible, foul-smelling fluid, with unerring aim.

The Badger is the largest of the British Carnivores, for, although the length of its body is not quite equal to that of the fox, in bulk it far exceeds that animal. It is a heavy, long and stout bodied animal, short-legged, with a tapering snout, and short, scrubby tail. It is fond of retired situations, such as sheltered woods, where it makes its large burrow or "earth." Its diet is decidedly a mixed one, as it feeds on roots, fruit, eggs, insects, small mammals, frogs, etc. When taken young it is easily tamed, and becomes devotedly attached to its owner. In a state of nature it is a very shy, wary animal, coming forth either in the early hours of the dawn or in the evening to feed, retreating rapidly to its "earth" at the least sound of danger, and therefore is seldom seen even by people living in the country. The American Badger is very similar in its habits and appearances.

There are two species of Ratel—one, the Cape Ratel (*Mellivora carpensis*), occurs in South Africa; the other, the Indian Ratel (*M. indica*), being found in India. The animal is also known as the "Honey Badger," and is one of the exceptional animals whose colour is lighter above than below. Its stiff, wiry hair is ashy-grey on the upper surface, while on the under surface the muzzle, limbs, and tail are black. Sleeping in its burrow during the day-time, it issues forth at sunset to seek for the nests of the wild bees, and for the birds, small mammals, and worms upon which it feeds.

The Grison is a weasel-like animal, found only in South America, and distinguished from its nearest relatives, the martens and weasels, by the fact that the colour of the upper is lighter than that of the lower surface of the body, the former being grey, and the latter dark brown.

The Glutton, or Wolverene, is the largest of the Weasel group, and is found over the greater part of the northern regions both of the Old and New Worlds. It attains to a length of some three

feet four inches, ten inches of which go to the tail. It has a dog-like snout, a broad or rounded head, short ears, an arched back, a short bushy tail, and long, dark-brown or almost black fur. Its name of Glutton is due to the mythical account of its habits given by an early writer, Olaus Magnus, and probably few other animals have given rise to so many or such wild fables. For its size it is a powerful animal, and it is noted for its excessive cunning.

Looking at the exterior of the Kinkajou (*Cercoleptes caudivolvulus*), one would feel almost inclined to place it among the lemurs; for, like them, it has a prehensile tail which can be coiled round branches to help its progress, precisely like that of a New World monkey. But it must be remembered that the possession of a prehensile tail is no sign whatever of any relationship between the animals possessing it. The Kinkajou is a pretty, innocent-looking little animal with a body about a foot long and a tail some eighteen inches in length, covered with soft brown fur. It feeds upon fruit, eggs, insects, birds, etc. It is found in Mexico, Guatemala, and in the great forests of Peru and North Brazil.

The Racoons form a small family of curious bear-like animals, of small size, and differing a good deal in external appearance, although agreeing closely in all essential particulars. The four genera are found only in the New World; their northern limit is British Columbia, while southwards they reach to Paraguay in Central South America.

The great Polar Bear is a gigantic animal, often attaining a length of nearly nine feet, and is proportionally strong and fierce. It is distinguished from other bears by its narrow head, its flat forehead in a line with the prolonged muzzle, its short ears, and long neck. It is found over the whole of Greenland, but its numbers have greatly decreased of late years. As the Polar Bear is able to obtain food all through the Arctic winter, capturing the seals as they rest on the ice by their *atluk* (or escape-hole), there is not the same necessity, as in the ease of the vegetable-eating bears, for hibernating. In fact, the males and young females roam about through the whole winter, and only the pregnant females retire for the season, making for themselves a cave in the snow, in which, in the spring, the young cubs are born. The under-sides of the feet are partially covered with fur, which enables the Polar Bear to get a better grip upon the ice than if its pads were naked

Young Syrian Bear

Brown Bear

Young Somali Hyenas

Grey-maned Hyena

and horny as in other bears. The seals are undoubtedly its chief source of food, but it will also gladly feast upon whale when it gets a chance. It is one of the few mammals which extend right round the Pole, and is, of course, a purely Arctic animal.

The Brown Bear (*Ursus arctos*) is a familiar object in most collections of wild animals, either in zoological gardens or travelling shows. In Roman and pre-Roman times it was found in Britain. It has a wide distribution, being found in many parts of Europe, in Siberia, Kamtschatka, Japan, and parts of the Arctic regions of North America. It is about six feet long, and from about three to four feet high at the shoulder. The fur is longish, rather woolly, and of a dark-brown hue. It lives a solitary life, and, like many of its kin, hibernates during the winter months. It is the opinion of Lydekker and other well-known zoologists that a very large proportion of the many species of Bears which have been from time to time described are really to be regarded as slight modifications or varieties of the Common European Brown Bear (*Ursus arctos*); and if this theory be accepted, then the Syrian Bear, the Isabelline, the Algerian, the Grizzly of North America, the Japanese, and the Kamtschatkan Bears must be considered as merely varieties. The Malayan Sun Bear (*Ursus malayanus*), the Tibetan Blue Bear (*U. pruinosus*), the Peruvian Spectacled Bear (*U. ornatus*), and the Sloth Bear (*U. labiatus*) of India and Ceylon, are distinct species.

The **Cynoidea,** or dog-like animals, form the most compact of the three divisions of the split-footed Carnivores. Only four genera are contained in the group, namely the Dogs, Wolves, and Foxes (*Canis*), the Long-Eared Fox (*Megalotis*), the Racoon-Dog (*Nyctereutes*), and the curious hyena-like *Lycaon*. The dogs form a sort of connecting link between the cat-like species of Carnivores on the one hand, and the bear-like group on the other. In the matter of being digitigrade[1] they agree with the cats; the number of their teeth agrees with that of the bears; in the character of the skull they come just half-way between the two. The numerous members of the genus *Canis* can, according to Professor Huxley, be divided by certain cranial characters into two series: the fox-like, or "Alopecoid," and the wolf-like, or "Thooid"—the Lycaon being distinctly "Thooid." Taking this

[1] Digitigrade—walking on the toes.

arrangement, under the fox-like series would be included the Arctic Fox, the Silver-Backed African Fox, the Fennec, the Common Fox, the Virginian Fox, and the Kit Fox. Under the head of the dogs proper would be included the Dingo, the Wolves, the Japanese and the Red Wolf of America, the Prairie Wolf, and the Jackals. The various and very numerous breeds of domestic dogs afford an important and striking object lesson in variation produced through methodical selection and breeding. The ancestry of the Dog may be concisely summed up in the words of the late Charles Darwin, who wrote: "It is highly probable that the domestic dogs of the world have descended from two good species of wolf (*Canis lupus* and *C. latrans*), and from two or three other doubtful species of wolves (namely, the European, Indian, and North African forms); from at least one or two South American canine species; from several races or species of the jackal; and perhaps from one or more extinct species"; and that the blood of these, "in some cases mingled together, flows in the veins of our domestic breeds."

The most southern point now inhabited by the Arctic Fox (*Canis lagopus*) is Iceland, but remains show that formerly it ranged as far south as Britain and Germany. It is of particular interest as being one of the few animals which change their dress to a complete white in winter. In its white winter coat it is known as the "White Fox," and in its bluish summer garb as the "Blue Fox."

The Common Fox (*C. vulpes*) is not only a native of Great Britain, but extends as far east as Egypt. Its bones occur in the red crag of Pliocene times, showing that it is a truly indigenous British mammal.

The European Wolf (*C. lupus*) is distributed over the greater part of Europe, Northern Asia, and North America, and was formerly an inhabitant of Great Britain, where it lingered in Ireland to so late as about 1770, the last of the Scotch wolves having been killed about 1743. In the twelfth century they were hunted in the New Forest, and in the reign of Elizabeth haunted Dartmoor and the Forest of Dean. The Wolf measures some five feet in length from snout to tail, and stands about thirty-two inches high at the shoulder. The skin is of a dark yellowish-grey colour, or sometimes almost black, occasionally white. The muzzle is

long and pointed, the ears are upright and pointed, and the eyes set obliquely, giving a very sinister expression to the face. The bushy tail is not curled like a dog's, but held down almost between the legs. The Wolf never barks—that is entirely a civilised habit—but the animal gives vent to the most horrible and ghastly howls. Indeed, the howling of Wolves borne on the wings of the wind over the lonely snow-clad wastes is a sound which once heard can never be forgotten.

Next to the wolf the Jackal (*C. aureus*) is the most important wild member of the Dog tribe. It is a much smaller animal than the wolf, not exceeding thirty inches in length, and seventeen in height at the shoulder, and has a longer and more pointed muzzle; its fur is of a dusky-yellowish colour. It is a cowardly animal, blessed with a most evil smell and with a voracious appetite, and lives largely on carrion. It haunts the outskirts of towns and villages, where it acts as a natural scavenger, devouring offal and garbage, but always ready to carry off poultry, lambs, or kids, should the opportunity arise. The African Black-Backed Jackal (*C. mesomelas*) is an inhabitant of South Africa, and is easily distinguished from other species by the black-and-white mottlings on its back.

The Lycaon, or Cape Hunting Dog (*Lycaon pictus*), has gained its popular name from its habit of hunting in packs. It bears a singular resemblance to the hyena, and was in fact first described as the Hyena-Dog.

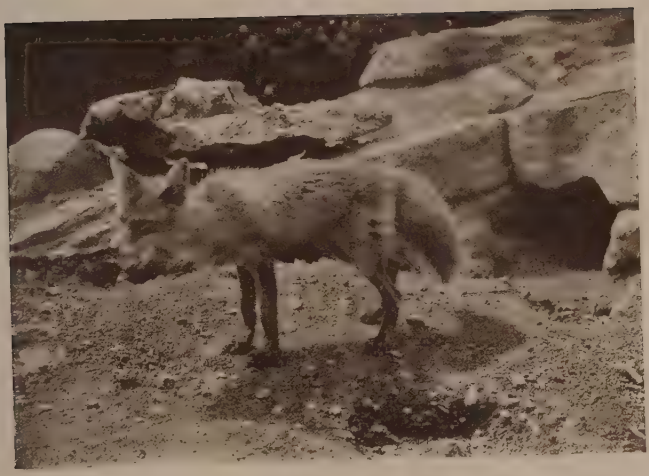
Of the **Æluroidea,** or cat-like Carnivores, the Hyenas and the Aard-Wolf most closely approach the dog-like group. The Aard-Wolf (*Proteles cristatus*), inhabits the southern part of Africa, where its range is almost co-extensive with that of the brown variety of the hyena. It has the sloping back of the hyena, owing to its forelegs being longer than the hind legs; but its head is quite civet-like, the snout being long and pointed. It is nocturnal in its habits, and constructs a subterranean burrow, at the bottom of which it lies concealed during the daytime, coming forth at night in search of prey, which consists chiefly of white ants or termites, though it takes toll of the young lambs and kids, killing them apparently chiefly for the sake of the curdled milk in their stomachs.

To the Civet family belong the Civets, or Civet Cats (*Viverridæ*)—

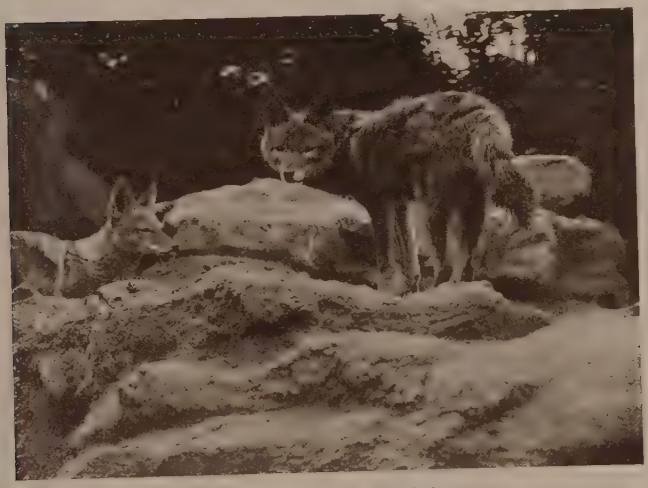
from which the well-known perfume is obtained—the European Genette, the Ichneumon or Mongoose, and the less familiar Paradoxure, and the Binturong. The latter was formerly placed in the Racoon family, to many members of which it bears a strong yet really quite superficial resemblance, the formation of the skull and teeth plainly showing its Civet character.

The Spotted Hyena (*Crocuta maculata*) is a native of South Africa, extending from Abyssinia and the Soudan on the north, where it meets with its striped brother, to Cape Colony. The skin is of a yellowish-brown ground tint, irregularly blotched with circular black spots. On the back of the neck and on the withers it has a quantity of long, stiff hairs, forming a kind of reversed mane. The fur is coarse and bristly, its character adding greatly to the animal's singularly repulsive appearance. The Striped Hyena (*Hyæna striata*) is found over the northern part of Africa, and extends into Asia, where it ranges over Asia Minor and Persia, and through India to the foot of the Himalayas. In ground colour it resembles the Spotted Hyena, but instead of being marked with spots its hide is covered with complete black transverse bands, like the hoops of a barrel, which extend downwards on to the legs. It is also very similar in its habits, following the lion to feast upon his leavings, prowling round camps, villages, and towns to pick up offal, frequenting the Arab cemeteries to dig up and devour the dead. Cowardly, ugly, singularly repulsive of habit, the Hyenas are nevertheless extremely useful animals in the tropical countries they frequent, for they act in conjunction with the jackals and vultures as natural scavengers, devouring the dead bodies of animals which would otherwise quickly poison the air.

The Cheetah, or Hunting Leopard (*Cynaelurus jubatus*), is separated from the true Cats by a number of characters: the claws are non- (or at least but partially) retractile, the legs are longer, and in the position of the molar teeth and the structure of the muscles there are characteristic distinctions. The Cheetah occurs in India, Persia, Turkestan, and Africa, and is about the size of a leopard, with a bright reddish-fawn-coloured coat, covered with numerous single black spots. As one of its popular names implies, it is used for sport, chiefly in the hunting of antelopes, and is capable of at least partial domestication, becoming attached to those who tend it.



Fox



African Black-backed Jackals

Leopard

Jaguar

The Wild Cat (*Felis catus*) was at one time common in the woods and forests of Great Britain, but is now confined to one or two remote districts in Scotland, and is also found over the greater part of Europe and Northern Asia. The true Wild Cat differs from the domestic races (which are probably descended from the Eastern *Felis caffra* and *F. maniculata*, both of Egyptian origin) by its longer body and limbs, and shorter and thicker tail.

Largest of the American Cats, the Jaguar (*Felis onca*) is a very handsome animal. It has a long, stout body and short limbs; and the coat very much resembles that of the leopard, the spots, however, being larger and more definitely arranged in groups. It is arboreal in habit, frequenting the wooded banks of the great rivers, and the reed-bordered lakes. It extends from the southern regions of the United States, through Mexico, Central America, Brazil, as far south as Paraguay and the Argentine. Its common prey is the capybara, but it also lives on fish, turtles, and at times commits serious ravages among horses and cattle.

The Puma (*Felis concolor*), the "American Lion," as it is called in the north, is rather smaller than the jaguar, and has a wider range, being found in the cold regions of the Straits of Magellan up to 50° or 60° N. latitude. In appearance it is not unlike a small lioness, having a tint somewhat similar to the tawny colour of the African lion, but darker and greyer. Unlike the jaguar, the Puma avoids water, although well able to swim when necessary. It is as much at home in trees as on solid ground, and is a terror to the monkeys which abound in the forests of South America. It is, however, far more cowardly than the jaguar, and is not feared by the natives to anything like the same degree.

Another spotted American Cat, with a range corresponding closely to that of the jaguar, is the Ocelot (*Felis pardalis*). Its greyish or tawny skin is marked by broadly sweeping rows of longitudinally elongated spots of large size. The head is also beautifully striped, and the tail ringed with black. It is about four feet long from the snout to the tip of the tail, and for its size has rather short legs. It is a handsome animal, and somewhat more shy than the puma.

The Common Lynx (*Felis lynx*) ranges over Europe, Asia, and America, according to Dr. Mivart, who considers the American and Asiatic forms as being identical with the European Lynx.

A Spanish form, however, *Felis pardina*, does appear to be a distinct species. The Common Lynx is found chiefly in Norway, Sweden, Russia, and Northern Asia, and in the mountainous districts of Central Europe. The animal attains a much larger size than any of the ordinary wild cats, being as much as forty or fifty inches long from the tip of the nose to the root of its tail. It is also readily distinguished from the Cats proper by the shortness of its tail, which does not exceed six to nine inches, and by the greater length of the legs. Another distinguishing feature is to be found in the long, pointed ears, each with a tuft of long, stiff hairs on its tip; and still another is the length of the fur on the cheeks. The fur is of a reddish-grey colour, more or less spotted with red or dark grey, but the variations in marking and colour are very great in different individuals in different localities.

The Snow Leopard (*Felis uncia*), or Ounce, is a very handsome animal inhabiting Tibet and the highlands of Central Asia. Living at high altitudes, it preys upon the wild mountain sheep and goats, but is said never to attack man. Its fur is very thick and soft, and has a paler ground colour than that of the leopard, in which the spots are rather less defined. The tail is remarkable for its length, and is thick and barred and spotted.

The Leopard, or Panther (*Felis pardus*), is Asiatic and African in range. In size it is decidedly inferior to either the lion or tiger, being not more than some seven feet six inches from snout to tip of tail, and two feet seven inches high at the shoulder. The female is somewhat smaller than the male. The coat is spotted, so that the animal bears considerable resemblance to the South American jaguar, but a closer inspection shows that the latter animal has shorter legs, and the ring-like markings on its body enclose a central black spot, whereas in the leopard the best developed ring markings enclose only the same tawny ground colour as the intervals between the spots.

The Tiger (*Felis tigris*) is the largest and most magnificent of the great Cats, and is exclusively Asiatic, ranging northward into Siberia, the northern specimens always being characterised by their closer fur. A full-grown male Indian Tiger may measure from nine to twelve feet, or twelve feet two inches, a tigress from eight to ten feet, or perhaps, in very rare instances, eleven feet in length, the height being from three to three and a half feet, or rarely

four feet at the shoulder. The magnificent colouring of the coat, and the graceful, lithe lines and proportions of the head, body, and limbs, make the Tiger the most perfect and beautiful, as well as the strongest and probably most savage of the Cat tribe ; it is the very summit of perfection of the Carnivorous animals, for, majestic as the lion appears when viewed head on, he does not give the same impression of supremely agile strength. This is borne out when we come to compare the habits of the two animals, for, unlike the lion, the Tiger can climb trees, and will also voluntarily enter the water and swim considerable distances. Tigers habitually swim over to Singapore across the Johore Strait by way of the intermediate islands.

The Lion (*Felis leo*) is an inhabitant of Africa, India, and Western Asia, and differs from all other species of the Great Cats by the magnificently developed mane of the male. It also differs from the majority of Cats, in that it cannot climb. It is chiefly nocturnal in its habits, hunting alone, except from the commencement of the breeding season, when the lioness accompanies the male up to the time when the cubs begin to know how to fend for themselves.

CHAPTER XXIX

THE RODENTIA, OR GNAWING ANIMALS

"MICE, rats, and such small deer," to use Shakespeare's phrase, make up a great proportion of the order **Rodentia.** The biggest of them is only about the size of a small pig; while the common house rat, or the squirrel, may be taken as examples of the average size of a Rodent. But although small of size, they are very numerous in species and individuals, being extraordinarily prolific creatures, and, for the most part, remarkably destructive, while in the East, as one of the recognised carriers of plague, the rat is a serious pest to mankind. The destruction of grain by rats and mice amounts to many thousands of pounds in value annually.

The Rodents form a very definitely circumscribed order of the Mammalia, so that a cursory inspection of the jaws is always sufficient to decide whether a quadruped belongs to the Rodents or not, so characteristic is the dentition of the group. The teeth are only of two kinds, incisors and grinders, and the number of efficient teeth of the former kind is never more than two in each jaw. Almost throughout the order, indeed, there are actually, even from the first, only two incisors present; but in the hares and rabbits, and some allied forms, there are in the upper jaw, in addition to the working teeth, a pair of rudimentary incisors placed immediately behind the large ones, but quite incapable of taking any part in this business of gnawing, for which the latter are so admirably fitted. Their presence is, however, of interest as indicating the direction in which an alliance with other forms of Mammalia more abundantly supplied with teeth is to be sought. The great incisors possess no roots, but spring from a permanent pulp, so that they continue to grow during the whole life of the animal; and their form, and that of the cavity which constitutes their socket, is always that of a segment of a circle, in consequence of which they always protrude from the front of the jaws in the

same direction, and meet at the same angle. The canine teeth are entirely deficient, and behind the great chisel-sharp incisors there is on each side a toothless gap of considerable extent, beyond which come the grinding teeth. The order includes the Squirrels, Flying Squirrels, Marmots, Beavers, Dormice, Rats and Mice, Voles, Lemmings, Musk-Rats, Capybara, Porcupines, Agoutis, Guinea-Pigs, Picas or Tailless Hares, and the Hares and Rabbits.

The Common Squirrel is so familiar to every lover of animal life as to call for no description here. The graceful, impudent little fellow has a very wide range, being found all over Europe, parts of Asia, and probably Persia. The North American Grey Squirrel is a larger and less handsome animal. It thrives well in captivity, and has been established in several parks and estates in England. Unfortunately it does not appear to live on friendly terms with its smaller British relation, and has in several cases ejected the latter from its native haunts.

The Flying Squirrels, as they are called, may be distinguished from the others by the presence of a large fold of skin extending along the sides of the body, and including the limbs as far as the wrists and heels. In the case of the Common Squirrel it has been observed that in performing leaps of any considerable distance the limbs are stretched out, and the long, bushy tail extended, so as to give the animal as large a surface as possible; but in the Flying Squirrel, when the limbs are extended laterally the folds of skin become tightly stretched, and form a regular parachute, which seems to give the animal essential support in its most extensive leaps.

The Spermophiles, or Gophers, occur in North America from Mexico to the Arctic regions, but never to the east of the great central prairie region; and in the Old World they extend from Silesia, through Russia, and across Asia to the Amoor and Kamchatka. They are squirrel-like in form, and have rather short tails. They are sociable, living in companies or societies, and prefer dry sandy soil, in which they can easily make their burrows.

The Prairie Dogs (*Cynomys*) are stouter in form, and have shorter ears and tail than the gophers, and are peculiar to North America. The best known of the two species is the *Cynomys ludovicianus*, to which the name of Prairie Dog was first applied.

It measures about a foot in length, and on the upper surface of its body is of a reddish brown, with grey markings; the lower surface being brownish or yellowish white. These animals live together in great societies. At the mouth of every burrow there is a little hillock formed of earth thrown out of the burrow, and serving as a watch-tower. The burrows are usually very numerous, and placed near together, forming a regular colony or "village." A good deal of doubtful "natural history" has been written concerning the relations which exist between the little Prairie Dogs and the rattlesnakes and burrowing owls which frequent their colonies, and the "happy family" nature accredited by some authors to the association does not appear to hold good. The rattlesnake is known to have a weakness for Prairie Dog, and probably in most cases first devours the rightful owner of the burrow he inhabits; while the burrowing owl, which in other situations is known to dig its own subterranean dwelling, on these prairies saves itself the trouble by taking possession of a deserted abode of the Prairie Dog.

The true Marmots are nearly related to the prairie dogs, and are confined to the northern hemisphere, but are widely distributed over both continents. They are stoutly built little animals, and usually live in large societies in extensive burrows. They are the largest members of their family, the Alpine Marmots measuring more than twenty inches in length, and the Bobac about fifteen inches, exclusive of tail.

The Beaver is usually about two feet and a half long, and is, therefore, with the exception of the capybara, one of the largest of the Rodents. The general colour of the fur is reddish-brown on the upper surface, lighter and greyish below; the colour, however, varies a little in different individuals, being generally darker in specimens from northern localities. Formerly the Beaver ranged over the whole of Europe, including the British Islands. It has, however, practically disappeared from the southern parts of Europe, but is still met with in some parts of Poland, Russia, Austria, and the Scandinavian peninsula; and in Asia about the rivers of Siberia, and the streams flowing into the Caspian Sea. It is still fairly abundant in some of the more remote parts of the forests of North America. So much has been written upon the habits of the Beaver, and of the wonderful dams which it

constructs in the rivers it frequents, that it is unnecessary to restate these well-known facts here.

The largest and most typical family of the Rodents is the *Muridæ*, which includes the Rats and Mice, and their numerous allies. Wallace estimates the number of known species at 330, which is probably well within the mark. As might be expected in so large an assemblage of species, the variety of forms is very great, but, broadly, the Common Rats and Mice, which are only too familiar to most people, are characteristic types of the whole series. The family, however, includes jumping forms, swimming forms, arboreal and burrowing forms, and is almost absolutely cosmopolitan in its distribution. It includes, as well as the Common Brown Rat and the Common Mouse, the Black Rat, the Field and Harvest Mice, the Hamsters and Tree Mice, the Voles, Musquash, and Lemmings.

The last-named animals are among the most remarkable of the *Muridæ*, on account of the great migrations which they perform. These migrations do not take place with any rhythmic regularity, but from time to time the Lemmings start in vast swarms from their mountain fastnesses, and make their way in a straight line in some definite direction. Nothing seems to turn them from their course, and they go straight on over hill and dale, and across any lake or stream that may come in their way. Preyed upon by carnivorous beasts and birds, their numbers diminish as the march proceeds, and when they come to the cultivated regions, where they do fearful damage to the vegetation, man joins in waging war upon them.

Crotch, who has published two or three papers on the Lemming and its migrations, says that in Norway these animals always proceed from the central backbone of the country in an easterly or westerly direction, and that in either case the survivors of the march drown themselves—those that go westward in the Atlantic, those that go eastward in the Gulf of Bothnia.

The Common Dormouse is an elegant little somewhat squirrel-like creature belonging to the family *Myoxidæ ;* its fur is of a light reddish-tawny colour above, becoming pale and yellowish on the under surface. It is widely distributed in Europe, ranging from Britain and Sweden in the north to Tuscany and Northern Turkey in the south. Nocturnal in habit, the Dormouse sleeps

during the day in its nest or in some snug retreat, coming forth at night in search of its food, which consists of nuts, acorns, seeds, berries, and buds of trees and shrubs. It becomes very fat towards the close of the autumn, when it retires to its warm winter quarters to spend the cold weeks of mid-winter in sleep.

The Pouched Rats, or Pocket Gophers (*Geomyidæ*), constitute a family distinguished from all the preceding forms by the presence of a pair of great cheek-pouches opening *outside* and not inside the mouth. These cheek-pouches are hairy inside throughout. The best-known species, the Common Pocket Gopher (*Geomys bursarius*), inhabits the whole valley of the Mississippi, and extends northwards into Canada. Its form is stout and clumsy, but its coat is beautifully soft and velvety, and of a dull reddish-brown colour, with the feet and tail white.

The Jerboa (*Dipus ægyptius*) is a kangaroo-like little Rodent, having very long hind legs, a long tail terminating in a tuft of hair, and very short front legs. The eyes are large and expressive, and the little creature has a singularly graceful, pretty appearance. It has a fairly wide range, being found in South-Eastern Europe, Northern Africa, Syria, Arabia, Central Asia, and India and Ceylon. It lives in communities, the members of which construct their burrows in dry sandy situations. When alarmed it progresses at a very rapid rate, bounding over the ground so quickly and lightly that the motion is more like that of a bird skimming close to the surface of the ground than that of a four-footed animal. Nearly related to the Jerboa is the Cape Jumping Hare, which is a larger animal, and inhabits a considerable part of South Africa.

The Coypu Rat (*Myopotamus coypus*), one of the largest of the Rodents, is found in nearly all parts of South America and on both sides of the Andes. It is usually about twenty inches long, but often attains to greater dimensions.

The most extraordinary-looking Rodents are the Porcupines, in which the greater portion of the hairs on part of the upper surface of the body have become converted into hollow pointed spines or quills. The Porcupines fall readily into two distinct groups characterised by structure, habits, and geographical distribution. In the strictly terrestrial species, or true Porcupines, which inhabit the warmer parts of the eastern hemisphere, the skull is rather more elongated than in the others; the molars are

Grey Squirrel

Sleeping Dormice

Porcupines

Coypu Rat

rootless when young, but become rooted after a time; the upper lip is furrowed; the tail is more prehensile; the soles of the feet are smooth; and the female has six teats. In the Tree Porcupines, which are all American, the skull is peculiarly short; the molars are always rooted; the upper lip is not furrowed; the tail is moderate or long, and generally prehensile; the soles of the feet are covered with wart-like tubercles; and the female has only four teats.

The Capybara (*Hydrochærus capybara*) is the largest of all existing Rodents, large specimens measuring over four feet in length. It is a stoutly built and massive animal, with limbs of moderate length, a large head with a very blunt muzzle, small eyes and ears, no tail, and both the fore- and hind-feet webbed. In general appearance the Capybara is more pig-like than any of its relatives. It is distributed over the whole eastern part of South America, from Guiana southwards to the Rio de la Plata and ranges westwards into the lower parts of Peru and Bolivia. The Capybaras frequent the borders of the lakes and rivers with which all this part of South America abounds, and are essentially aquatic in their habits.

In many respects the Pikas or Tailless Hares (*Lagomyidæ*) closely resemble the true hares, but they are distinguished by having only five molars on each side in each jaw, a depressed skull, short ears, limbs nearly equal in length, and no tail visible externally They are much smaller than any of the hares and rabbits, the largest being no larger than a guinea-pig, to which the animals have some resemblance; while in their habits they somewhat resemble the marmots. When feeding they often produce a chirping or whistling noise, whence the name of "Piping Hares" or "Calling Hares" has also been applied to them. They inhabit the northern and mountainous parts of Asia, and one species is also found in Europe, about the southern part of the Volga. A single species is found in North America.

CHAPTER XXX

SHREWS, MOLES AND BATS

The Insectivora, or insect-eating animals, are an interesting group of comparatively small Mammals. Though many have an external resemblance to various rodents, anatomically they are entirely distinct. Generally speaking, the Insectivora have short limbs provided with five toes, are "plantigrade"—that is to say, in walking they always plant the sole of the foot flat upon the ground—have long muzzles, and are usually clothed with fur. In their habits they are nocturnal, with one or two exceptions, and they pass the winter months as a rule in a state of partial or complete hibernation. They are shy animals, generally living concealed among the roots of trees or under herbage in the depths of forests. Many take possession of holes deserted by other animals, and some burrow in the ground and lead a subterranean existence. Their food consists mainly of insects, worms and snails, but this diet is not in all cases strictly adhered to, one species living on fish, while others will devour almost anything. The character of their teeth and the fact that these animals have a curiously scattered and isolated distribution point to their being a very ancient order of creatures. The incisor teeth are not chisel-like as in the rodents, but the first pair, placed on the sides of the jaws, are often longer than the others, and the upper molars are covered with a number of sharp conical cusps fitted for piercing the tough integument of many of the insects the animals devour. The Insectivora may be divided into two sub-orders—(1) the *Insectivora vera*, which includes the Hedgehogs, Tenrec, Moles, and Shrews; and (2) the *Dermoptera*, the so-called Flying Lemurs. The order *Chiroptera* comprises the Bats.

In Australia and South America the Insectivora are unknown, but they are widely scattered over other parts of the globe. In the British Isles the order is well represented, and in the West Indian

Islands, Madagascar, and Africa we find some of the most curious of these primitive creatures.

The True Shrews (fam. *Soricidæ*) have a much wider range than the rest of the Insectivors. They are graceful little creatures so like mice in appearance that they are popularly called "Shrew-mice." They have very long heads, long, sharply pointed snouts which project beyond the lower jaw, and small, beady eyes; the external ear (when present) is rounded and bears some resemblance to the human ear. The little creatures are clothed with fur, usually of the softest velvety texture, and they differ from all other Insectivors in having the first pair of incisor teeth long and sickle-shaped in the upper jaw, while those in the lower jaw are straight, sometimes curving upwards at the tips. Some genera are distinguished by having the teeth coloured a reddish-brown at the tips, others have ordinary white teeth. Shrew-mice have long, slender tails covered with fine hairs, and the male Shrews (and in some cases the females) have a gland in the side from which an unpleasant, musky odour is given forth, which no doubt is a source of protection to the animals. This scent is most pronounced in the large Musk-shrews of India (*Crocidura*) commonly called "Musk-rats."

The British species are the Common Shrew-mouse (*Sorex vulgaris*), abundant in most districts; the Pygmy Shrew-mouse (*S. minutus*), scarcer in England but more abundant in Ireland; and the Water Shrew (*Crossopus fodiens*), unknown in Ireland, but not uncommon in England and the South of Scotland.

The Common Shrew-mouse is about four inches long from the end of the snout to the tip of its long, square-sided tail. The colour of the fur is usually a reddish-brown, the under parts being paler, but the colour is to a great extent variable and specimens are occasionally banded with white. It feeds chiefly on insects and worms, which it roots up with its pointed, flexible snout, and varies its diet with slugs and snails. It makes its home in woods, under hedgerows and in ditches; and in such situations in the spring and summer its nest of grass and leaves may be found in a depression in the ground, well concealed under herbage. Litters of from five to seven are usually produced at a time, and the young ones are helpless little creatures, at first quite blind and toothless.

In disposition the Shrew-mouse is a fierce, pugnacious little animal, ready to attack all comers; two rarely meet without fighting, and if shut up together one is certain to be killed by the other. In a quaint old book, "The Historie of Four-Footed Beastes," by the Rev. Edward Tapsell, the Shrew is described as a "ravening beaste, feigning itself gentle and tame, but, being touched, it biteth deep, and poysoneth deadly. It beareth a cruel minde, desireing to hurt anything, neither is there any creature that it loveth, or it loveth him, because it is feared of all." All sorts of things were connected with this harmless little creature in olden times. If a cow's supply of milk ran short it was believed she had been bitten by a Shrew, and accidentally to touch one was looked upon as a sure sign of coming misfortune. As a remedy for "Shrew-bitten" animals a live Shrew was imprisoned in a hole in an ash tree and the twigs and leaves of the "Shrew ash" given to the sufferers. The Shrew also entered into all sorts of weird concoctions which were supposed to cure various evils—from inflammation to the bite of a mad dog.

In the autumn numbers of Shrew-mice are often found dead in gardens, hedgerows, and ditches, having, in all probability, succumbed for lack of their natural food; those sufficiently well fed hibernate through the winter. Shrew-mice are preyed upon by owls and weasles, and frequently killed by cats; the latter, however, do not eat them, probably on account of their strong musky odour.

The Pygmy Shrew enjoys the distinction of being the smallest of British Mammals. It is not, however, the least of its tribe, for there is an even more minute species belonging to the Musk Shrew family inhabiting Egypt.

The Water Shrew has a velvety black coat; the under parts are usually white, but some individuals of the same species are more or less dark all over. The feet and under-surface of the tail are furnished with fringes of stiff hairs, enabling the Shrew to swim with ease. It is, indeed, thoroughly at home in the water, and in the daytime may be seen indulging in all sorts of antics in clear streams. It is fond of running up the stems of water-plants, diving into the water, and frisking in and out the reeds and rushes. Its food consists of all sorts of aquatic insects and small crustaceans, and it is often to be seen running about over the bottom of the

stream turning over the pebbles with its long snout in search of fresh-water shrimps, of which it is particularly fond.

When under water the Shrew becomes covered with quantities of minute air-bubbles, which are entangled in the short hairs of its velvet coat, giving it a glistening silvery skin; and on emerging from the water its fur is perfectly dry. It makes its home in the banks of streams, in burrows which it excavates for itself, and if it is disturbed will at once plunge into the water.

All three British species have red-stained teeth, but those of the Water Shrew are not so highly coloured.

Other true Shrews are the Short-Tailed Shrews (*Blarina*) of North and Central America; the Browning Shrews (*Anurosorex*) of Assam and North-Western China; the Swimming Shrews (*Chimarrogale*), of which species are found in Japan, Borneo, Mount Kina Bahi and the south-western part of the Himalayan range; the Musk Shrews (*Crocidura*), which range over Central and Southern Europe, Asia and Africa; and the Web-Footed Shrew (*Nectgale*) of North-Western China.

The Elephant or Jumping Shrews are not true Shrews, but belong to quite a different family of the Insectivora—the *Macroscelidæ*. They are Shrew-like animals with the hind legs longer than the front ones, reminding one of miniature kangaroos, and the long snout is very flexible and can be bent in the manner of an elephant's trunk. These strange little creatures inhabit South Africa; they live among the bushes and grasses, and are nocturnal in their habits, coming out at dusk to hunt for insects. There are three genera, which differ in the comparative length of the hind legs.

The Hedgehogs and Rat Shrews are included in the family *Erinaceidæ*. The Common Hedgehog (*Erinaceus europæus*) ranges through the whole of Europe, temperate Asia, and parts of Africa. In England it is well known, and in different parts of the country is called a "Furze-Pig," "Hedge-Pig," and an "Urchin." The Hedgehog's chief characteristic is the thick coat of short, stiff spines which clothes its back and sides. Its legs are exceedingly short, and the forefeet are armed with very sharp claws; the neck is so short that the animal appears to have none; the snout is pig-like, and the eyes are small and beady.

Although its movements appear slow and deliberate the Hedgehog is able to get over the ground fairly rapidly, and at the least

sign of danger it rolls itself up into a ball, presenting a formidable array of spikes to the enemy. This it is able to do by the remarkable development of the larger of the muscles beneath the skin, peculiar to most mammals, called the *paniculus carnosus*. The spines themselves are very elastic, enabling the animal when rolled up into a ball to drop on the ground from a considerable height without being injured. The Fossil Hedgehogs of the Oligocene period were structurally very little different from the Hedgehogs of the present day, showing that they are one of the oldest living genera of mammals ; and it is in all probability their protective spiny armour that has enabled them to exist on the earth so long without changing their habitat or ways of life.

In its tastes the Hedgehog is decidedly omnivorous. It will eat insects and slugs, worms, small birds and mammals, eggs, lizards and snakes. The snakes it kills by a succession of bites, presenting its formidable spines to its victims should they attempt to retaliate.

Hedgehogs are said to pair for life. Four to six young ones are produced at a birth, which are blind and have soft, white, flexible spines.

In Burmah and the Malay region the Rat-Shrews (*Gymnura*) take the place of Hedgehogs. They show their affinity to the Hedgehogs in several anatomical details as well as in the structure of the teeth, but they have no spines and are clothed with a thick, rough fur.

The family *Talpidæ* comprises the Moles and the Desmans. They are nearly allied to the Shrew-mice, which they closely resemble in their structure, although from certain distinct characteristics they are placed in a separate family.

The Common Mole (*Talpa europæus*) is about five inches long. It is remarkable for the cylindrical shape of its body, at one end of which is a pointed snout and at the other end a short tail. The fur with which it is covered is thick and fine in texture, and the short hairs so set in the skin that the fur lies smoothly in any direction. The bones and muscles of the breast and fore-limbs are remarkably developed, the forefeet are shaped like little hands, the five digits ending in sharp claws admirably suited for digging. Indeed, the form of the Mole is most wonderfully adapted in every particular to the subterranean life it leads. The wedge-shaped

skull, the strong boring snout, and the spade-like hands, combined with the smooth, cylindrical body, all aid the animal in its marvellously rapid progress underground ; it may, in fact, be said almost to swim through the soft, loose soil in which it makes its burrows.

The Mole has no external ears, and its eyes are rudimentary, but not altogether absent as is commonly supposed ; they are very small and concealed beneath the fur which protects them from the loose mould as the animal burrows its way through the earth. Earth-worms and the underground larvæ of various insects constitute its principal food ; and the prey is probably discovered by hearing and smell, both these senses being strongly developed. The Mole is a very voracious animal, moreover, and will eat any small creature, alive or dead, that it may chance upon. It is, too, of a fierce disposition, and will fight savagely with others of its own kind; should one of the combatants be completely vanquished the victor will make a meal of it.

The American "Star-Nosed" Mole (*Condylura cristata*) is distinguished by having a curious radiating appendage on the end of its snout, and a very long tail. In its habits it much resembles the Moles of the Old World.

The Web-Footed Moles (genus *Scalops*), which also inhabit America, have webbed hind-feet, and from this fact one would naturally suppose them to be capable of swimming; they are actually described by some authorities as "aquatic" animals, but others state that this genus often lives far from the water and will not voluntarily enter it. The Desmans, however, which also have webbed hind-feet, are aquatic in their habits; they live in holes on the banks of lakes and streams, and spend a considerable part of their time in the water. The fore-limbs of the Desmans are not formed for digging like those of the other members of the Mole family, and from certain resemblances to the shrew the genus forms a connecting link between the two families.

The Bats (order **Chiroptera**) enjoy the distinction of being the only true flying Mammals. The flying squirrels and curious flying lemurs do not actually fly, but parachute by means of the folds of skin which unite the limbs. The scientific designation *Chiroptera* is derived from two Greek words, meaning respectively "hand" and "wing"; so the Bats may be described as "hand-winged" animals.

The fore-limbs of a Bat differ from those of the great majority of Mammals in being considerably larger than the hind pair. The four fingers of the hand are much elongated and support a delicate membrane which is continued along the arm and the sides of the body, and on to the hind-legs. Another membrane connects the hind limbs to the tail, which is generally very long. The thumb of the hand is short and provided with a stout, hook-like claw, by means of which the Bat hangs itself up to any suitable projection during its hours of rest. The wings of the Bat are of a leathery texture and entirely devoid of hair ; but the body is clothed with soft fur and much resembles that of a mouse—whence the old English name of "Flittermouse."

The senses of hearing and smelling are very highly developed, and experiments have proved that a Bat when deprived of its sight has no difficulty in avoiding obstacles, and can with perfect accuracy thread its way through a network of lines purposely placed across a room to test its powers. The cry is a high, shrill squeak, uttered when chasing prey on the wing, but the pitch is so remarkably high that the ears of few people are able to detect it.

The order Chiroptera is divided into two groups, one containing the Insect-Eating Bats, and the other the Fruit-Eating Bats. The first group (*Microchiroptera*) contains more than four hundred species. They are all of small size and usually possess a disagreeable odour. Though a few eat a certain amount of fruit, and others are blood-suckers, they are principally insectivorous, and are themselves preyed upon by owls and weasels.

The best-known Bat in Great Britain is the little Pipistrella. In its appearance, size, and colour it is more like a mouse than any other species. In all parts of the country and on the outskirts of towns the Pipistrella may be seen flitting about in the twilight, twisting and turning with wonderful rapidity as it hawks after the insects which venture abroad in the dusk. By day it hides in all sorts of crannies in old buildings and roofs, or in clefts of rocks, rarely choosing trees when other places are available. During the winter it hibernates, but is out and about again earlier than any of its English relatives. Towards the middle of March it is usually seen on the wing, and although normally of nocturnal habits it will sometimes appear in broad daylight. Small insects of all

kinds, particularly gnats, are captured by this little Bat, and in captivity it will readily eat raw meat.

The Noctule (*P. noctula*), the Long-Eared Bat (*Plecotus auritus*), the Greater Horseshoe Bat (*Rhinolophus ferrum equinum*), and the Barbastelle (*B. barbastella*) are other English species, the last being somewhat rare.

The Noctule is a member of the genus *Pipistrellus*. It is distinguished from the Pipistrella by its larger size—the Noctule measures three inches and has a wing expanse of from thirteen to fourteen inches, while its smaller relative is less than two inches long with a wing spread of eight inches or a little more. In its habits the Noctule is gregarious; it haunts the neighbourhood of trees, and passes the day in hollow tree trunks or under the eaves of houses. Cockchafers appear to be its favourite food, and on summer evenings it may be frequently seen hawking after the insects round the oak-trees.

The Long-Eared Bat is a small species, but the ears, which are twice the length of the head, make it appear larger than it actually is. Although not uncommon it is not so often seen as many other Bats, as it comes out later than most of the species in search of prey. When resting this Bat usually folds its long ears away beneath its wings.

The Greater Horseshoe Bats are distinguished by the curious leaf-like appendage on the nose, which has somewhat the form of a horseshoe. This peculiar appendage is possessed in a greater or lesser degree by a number of species known as "Leaf-Nosed Bats." The Lesser Horseshoe Bat (*R. hipposiderus*) is also found in England.

The Fruit Bats, which are confined to the warmer regions of the Old World, are much larger than the insect-eaters. There are many points of difference in the structure of the two groups, one of the chief being in the formation of the teeth. In the Insect-Eating Bats the molar teeth are armed with sharp cusps, while the Fruit Bats have smooth-crowned molar teeth divided by a deep groove, perfectly adapted for crushing up the soft, pulpy fruit on which they feed.

The largest of the Fruit Bats are the "Flying Foxes" (*genus Pteropus*), so called from their long, fox-like muzzles. The Malay Fox Bat (*P. edulis*) is the largest of all known Bats, and has a

wing expanse of five feet. In describing the Australian Fruit Bats (*P. poliocephalus*) Professor H. N. Moseley writes—" In a dense piece of bush, consisting principally of young trees, the trees were hung all over with these bats, looking like black fruits. As we drew near, the bats showed signs of uneasiness, and after the first shot were rather difficult to approach, moving from before us and pitching in a fresh tree some distance ahead. The bats uttered a curious crackling sound when disturbed. They were in enormous numbers, and although thousands had been shot by a large party got together for the purpose, their numbers were not perceptibly reduced. They do great harm to the fruit orchards about Parramatta, and the fruit-growers there organise parties to shoot them."

CHAPTER XXXI

PRIMATES—APES AND LEMURS

In the **Primates** we reach the highest and most complex form of mammalian life. The animals included in this group are readily divided into two divisions, namely (1) the *Lemuroidea*, or Lemurs, and (2) the *Anthropoidea*, or Apes and Man ; for though for purposes of classification it is permissible to assign Man to a special family (*Homo*), he and the Apes are not separable into diverse orders among the Mammalia. The differences of structure between the lowest of the Apes and the higher are far greater than those which exist between Man and any Anthropoid Ape ; indeed, in their expressions of mental activity, intellectual or emotional, the Anthropoid Apes in some respects come very near the lowest existing types of the human race.

While it is impossible to regard any of the existing species of Anthropoid Apes as in the direct line of human ancestry, it is equally impossible to establish any fundamental distinction in physical structure between Man and the Anthropoid Apes. Generic differences there are in abundance, but they establish only a difference of degree, and not of kind. The leading feature in the evolution and separation of Man from amongst other animals is undoubtedly the relatively enormous size of his brain, and the consequent increase in its activity and ability to store up individual experience—what Sir E. Ray Lankester has so aptly described as its "increased educability." Year by year, piece by piece, the evidence of the steps by which Man gradually emerged from the terrestrial animal population, which is so strictly controlled and moulded by natural selection, is being brought to light, and undoubtedly those links in the chain which connects "civilised" Man with his humbler anthropoid ancestors, which are still required for its completion, will eventually be discovered.

The forests of Madagascar, of Western and Eastern Africa,

and of some of the Asiatic islands, are the homes of several kinds of animals which are not unlike the Monkeys in some respects, but which differ from them in their habits of life, and to a certain extent in their anatomy. Most of them are in the habit of hiding all day, and of moving with great vivacity at dusk and during the night-time. Their gliding, noiseless motion amidst the dense foliage of the tropical woods during the dark hours, and their restless activity in searching for their food during the short twilight, were considered to resemble the fitful apparitions of sprites, spectres, and hobgoblins, and hence Linnæus gave them the name Lemurs, taking the term from the Latin *lemures*, "ghosts." The name has been adopted popularly, so as to include all the kinds which, with some structural resemblance to the Monkeys, are for the most part nocturnal in their habits. The use of the name in this manner has, however, been productive of some confusion, for it was especially given to one genus which is restricted to the island of Madagascar, and of which the Ring-tailed Lemur is a species familiar to all visitors to the Zoological Gardens. In scientific language, the genus Lemur and all the Lemur-like animals are classed together under the term *Lemuroida*, and it is in this its wide significance that the term is now used.

The **Lemuroida** as a group have some characters in common. They are easily recognised by their little hairy "hands" at the ends of the arms and legs, large furry tails, slim furry bodies, long ears, great staring eyes, and a muzzle like that of a small fox. The hinder thumbs, or great toes, are in most very large, strong, opposable to the other digits, and capable of much movement. Furnished also with well-made thumbs on the hands, they have a great power of grasp, and of clasping boughs and large creeping plants during their active climbing and jumping. The fox-like face has no trace of that human expression which is to be found in even the lowest of the apes. The long, furry tail is prehensile, and there is never any trace of cheek pouches. They agree with other Primates, however, in having opposable thumbs and toes, as noted above, and in the flattened digits, and breast-bone mammæ. The front limbs are always shorter than the hind limbs. The geographical distribution of the Lemurs is remarkable. Out of the fifty species referable to seventeen genera, thirty-six are confined to Madagascar and some small neighbouring islands, the remainder being limited

Chackma Baboon

Sacred Baboon

Japanese Ape

Young male and female Chimpanzee

to Ethiopian and Oriental regions. Although so restricted at the present day, fossil remains show that the Lemurs were more widely distributed over the earth in past times.

The Ring-tailed Lemur (*Lemur catta*), with its pretty chinchilla-grey tints, and banded tail of black and grey rings, is perhaps one of the most familiar of the Lemur tribe. Its hind-limbs considerably exceed the fore-limbs in length, giving the animal a curious attitude of back-arching when on the ground. The face is pointed, and the eyes large, soft, and expressive. The fore-foot is a kind of diminutive flat-nailed hand, with a proportionately short thumb, and is hairy above but naked below, and all the fingers have expanded cushions on their last joints. The hand is not capable of being closely clenched, and the thumb only reaches to the middle of the palm. The hind-feet are large, and there is a strong great-toe-thumb. Moreover, a true claw adorns the next toe, and in many other respects there is a certain agreement between the foot and the hand. Both are black-soled, and have a wonderful tracing of pronounced cross-lines, furrows, and folds. The mammæ, or teats, are two in number, and are placed near the armpits. Usually the species of Lemur have but one, or at most two, little ones at a birth, and the period of gestation is about one hundred and ten days, the young Lemur being born almost naked. Its hairs are short and sparsely distributed, except on the head, where they form a kind of belt around the eyes. It clings to its mother's fur, and, holding on to that over her abdomen, it lies across her, so that when she draws up her legs she either hides the little one effectually, or it may be seen, hairless, in the folds of her groins. After a while, and as the young Lemur becomes better clothed and stronger, it leaves its snug retreat, crawls up on to the mother's back and shoulders, seizes her fur, and holds on with such tenacity that she can jump and bound about without unseating her little burthen. Social, and banding together in troops, Lemurs feed on the fruits of the forest, and occasionally, it is stated, on insects and small birds. The Weasel Lemur, Black Lemur, White-fronted Lemur, and Ruffed Lemur are easily recognised by their popular names, and call for no special description.

The African Slow Lemurs are a very sad, weird, slow-going set, totally different from the active creatures just described.

They are never seen to spring and rush about, but are most deliberate in all their movements; hence their name, the Slow Loris. Their body and limbs are not made for rapid movement. The limbs are nearly equal in length, and the head is globular; the ears are short, as is also the tail, and the body is clothed with short hair. The Asiatic Slow Lemuroids appear to resemble their African relations very much in their general attributes; they are very sluggish in their movements, and nocturnal in habit.

The Aye-Aye (*Cheiromys Madagascariensis*) is one of the most remarkable animals in the world, both on account of its peculiar squirrel shape and lemur-like construction, and of its habits. It is about three feet in length, including the long tail, and there is a half-fox, half-lemur look about it, with a little of the squirrel. The hind-feet at first sight are like those of a monkey, as are also the limbs; but the hands are not in keeping with the rest, for the fingers are of all kinds of lengths, and the middle one looks as if it were atrophied and wasted. The tail is longer than the body, straight, very bushy (being covered with long, coarse hairs), and flexible. The ears are large, widely opened, spoon-shaped, and nearly naked; the head is broad; in the front of the jaws are four large teeth—two in the upper, and two in the lower jaw—shaped like those of a rodent, and there is a gap in the gums between them and the next teeth, which still further heightens the rodent-like aspect of the jaws. On the whole, the Aye-Aye presents more resemblance to the Lemuroids, and less to any other animal. Its large open ears, the eyes looking straight forward, the nostrils placed at the end of the snout, the absence of any groove in the upper lip, the nature of the fur, so furry below and hairy above on the skin, are interesting points to those who care to compare this animal with the Lemuroids and Rodents. The skeleton resembles that of the Lemuroids and Apes, and there are so many points of difference from the Rodents—although the skull at first sight looks like that of a rat—that this very exceptional creature is classified with the Lemuroids from its partial resemblance to them and the Monkeys.

The Monkeys of the New World are distinguished by their generally prehensile tail, and the broad end to the nose, the openings of the nostrils, which look outwards, being separated by a thick gristle. It is from this latter characteristic that the New World

Monkeys are termed *Platyrrhines;* while the Old World Monkeys have only a thin gristle in the same place, so that the nostrils are not wide apart, but open in front, more or less like those of man and dogs, or "looking downward," whence the name *Catarrhines*, under which the Old World Monkeys are grouped.

We may begin our examination of the broad-nosed or **Platyrrhine** Monkeys of the New World with the pretty little Marmosets, or, in scientific language, the *Arctopithecini*, a word which means Bear-Monkey. There are two genera in this division—(1) the genus *Hapale*, which contains the Marmosets proper, and (2) the genus *Midas*, which contains the Tamarins—they are characterised by having thirty-two teeth, and the tail not being used as a prehensile organ. The face of the Marmoset is short, and the broad division between the nostrils, which open widely apart and outwards, is very evident. Very remarkable are the feet, for in these Monkeys the toe-thumb is not widely separated from the other digits, but is close to and parallel with them, so that they resemble the human foot more than the human hand. The insectivorous and carnivorous propensities of these little creatures are shown in the form of their nails, which are curved claws. In the hand the thumb is not capable of being separated widely from the other fingers, and it has a sharp claw on it, so the resemblance to a true hand is small, and the likeness to a "paw" is great. In their natural state the Marmosets lead an arboreal life, and assemble in small companies of half a dozen or more, climbing the tall trees of the Brazilian forests, and jumping from bough to bough with squirrel-like activity. Opinions seem to differ considerably regarding their intelligence and affection, for while Broderip would have us consider them as displaying extraordinary affection, Swainson describes them as mistrustful, indifferent, and not particularly intelligent. Certainly those which came under my own notice in Brazil did not appear to display much affection for their owners, generally shrinking from being handled, and threatening with their sharp little teeth, but watching what was going on around them with apparent interest.

The Tamarins have the upper front teeth placed close together; and the lower, which are broad and truncated, project forwards. They live in the forests of Panama, Peru, and the Brazils, and are restless, active little creatures, about the size of a squirrel. In general appearance they resemble the marmosets.

The Sakis (*Pithecia*) Monkeys are an interesting group, sometimes called "Fox-tailed Monkeys" from the full bushy tail with which they are furnished. Bates gives the following account of his first sight of the Scarlet-faced Saki :—

"Early one sunny morning in the year 1855, I saw in the streets of Ega a number of Indians carrying on their shoulders down to the port, to be embarked on the Upper Amazon steamer, a large cage, made of strong lianas, some twelve feet in length and five in height, containing a dozen monkeys of the most grotesque appearance. Their bodies (about eighteen inches in height, exclusive of limbs) were clothed from neck to tail with very long, straight, and shining whitish hair. Their heads were nearly bald, owing to the very short crop of thin grey hairs, and their faces glowed with the most vivid scarlet hue. As a finish to their striking physiognomy, they had bushy whiskers of a sandy colour, meeting under the chin, and reddish-yellow eyes. The scarlet-faced monkey lives in forests which are inundated during a great part of the year. It is never known to descend to the ground; the shortness of its tail is therefore no sign of terrestrial habits, as it is in the macaques and baboons of the Old World."

The Howlers (*Mycetes*) are the largest of the Monkeys of the New World, some being nearly three feet in length, without counting the long, prehensile tail; they have movable thumbs on their hands, a hairless space underneath the tip of the wonderful tail, and a peculiar formation of the vocal apparatus which enables these Monkeys to produce the extraordinary far-reaching yells and howlings for which they are famous. In describing the Red Howler, Waterton states that "nothing can sound more dreadful than its nocturnal howlings. While lying in your hammock in those gloomy and unmeasurable wilds you hear him howling at intervals from eleven o'clock at night until daybreak. You would suppose that half the wild beasts of the forest were collecting for the work of carnage." Salvin estimated the howling voice to carry a distance of quite two miles through the forest, and "when the sound came over the Lake of Yzabel unhindered by trees, a league would be more like the distance at which the cry would be heard."

The Capuchin (*Cebus*) Monkeys are probably the most familiar of the South American tribes, for they are more frequently than

any other kind of Monkey the companions of the wandering Italian organ-grinders and accordion-players that haunt our suburban streets and country towns. In captivity they are docile, gentle creatures, and have rather human, inquisitive faces, and when pleased give vent to little cooing, chirruping sounds. The face is round, the muzzle but slightly projecting, and the tail is not so prehensile as in the Howlers and Spider Monkeys. They are arboreal in their habits, feeding upon fruits, insects, and robbing birds' nests, devouring the eggs and nestlings. They are wonderfully active, leaping from branch to branch with the greatest speed and agility.

The Spider Monkeys (*Ateles*) have small heads, long necks, and exceedingly long arms, legs and tails; some are covered with a soft fur, and in others it is harsh, and the hairs are long and rigid; all have the thumbs of the hands either absent or just visible as slight projections. The feet are long and have well-shaped toe-thumbs. The activity of these Monkeys is marvellous, as they swing from bough to bough through the dense forests, their long hairy arms and legs giving them a strange appearance suggestive of some great spectral long-legged spiders. Bates, who observed them during his wanderings on the Amazon, both in the forests and as captive pets, describes them as very intelligent, sociable creatures.

The Apes of the Old World differ from those of the New World in many points. The tail, where present, is never prehensile, the nostrils are not wide apart but open in front, and, as already stated, give to these Old World Primates the name **Catarrhine**; cheek-pouches may or may not be present, and many have curious, sometimes large and vividly coloured, callosities on their hind-quarters.

The Baboons (*Cynocephalus*) have a dog-shaped head, a long muzzle, and a curious fullness on either side of the long nose, which gives them a very characteristic appearance. Their eyes are close together and are deeply set, their ears are moderately large, and the neck is rather long. When resting, the favourite position is squatting on their hind-quarters in rather a dog-like manner. They trot and canter, but rarely leap or bound over the ground, and scramble and climb up rocks with considerable agility. They have cheek-pouches, and the characteristic, often vividly coloured,

callosities on their hind-quarters. These Cynocephalic Dog-headed Apes have some singular structural resemblances to the higher Apes and Man on the one hand, and to the lower carnivorous mammals on the other.

The Baboons are widely dispersed about Africa, frequenting mountains and woody places, and rather avoiding forest land. They extend into Arabia, and a little black one lives in the island of Celebes, in the Philippines, and in the Islet of Batchian, close by. Some kinds differ but slightly from one another, and those of one part of the African continent appear to resemble those of other districts in their several shapes and habits, and yet to have different-coloured hair, hence much confusion has arisen regarding the races and species of the genus. The possession of a good tail constitutes a very good characteristic, and by the presence or comparative absence of this member the group may be divided into two: the division in which the tail is never very long, sometimes short, and with or without a terminal tuft, includes the Sacred Baboon (the Thoth of the ancient Egyptians), the Gelada Baboon, the Pig-tailed or Chacma Baboon, and the Common and Anubis Baboons; while the second, nearly tailless, division includes the Mandrill, the Drill, and the Black Baboon.

The Macaques live in India, Tibet, North and South China, Japan, and in some of the great islands of the archipelago, in Africa, in Barbary, but not south of the Atlas range, and in Europe, on the Rock of Gibraltar. They may be said to form a group which connects with the Guenons on the one side, and the Baboons on the other. They all have cheek-pouches, and callous pads, or callosities, on their hind-quarters. Like all the Monkeys which are lower in the animal scale than the great man-shaped Apes, the Macaques have narrow wrists, long finger-bones, and a short and backwardly placed thumb. The length of the tail depends upon the number of the tail vertebræ, and their size. In the Gibraltar Ape there are only three of these caudal vertebræ, but in the Bhunder there are fifteen, and sometimes eighteen, in the tail. Living upon a great variety of food, and using their jaws with rapidity, these Monkeys are furnished with a curious modification of a muscle that exists in Man and the higher Apes, called the two-bellied or digastricus muscle, which assists in

a very important manner during the act of swallowing. The large Common Macaque, and the Round-faced or Formosan Monkeys, and the Bonnet Monkey, may be said to represent the long-tailed kinds; the Bhunder (*Macacus Rhesus*), or Rhesus Monkey, has a tail of moderate length; the Pig-tailed and Belanger Monkeys are typical of the short-tailed kind; and the tailless includes the Magot or Gibraltar Ape, which is very baboon-like both in appearance and general habits.

The Guenon (*Cercopithecus*) Monkeys have gained their popular name from their odd grimaces and gestures. They are characterised by their long hind- and short fore-limbs, long tails, and capacious cheek-pouches. In the wild state they assemble in troops in the forest, for they are essentially tree-dwellers, and make raids on all sides of their favourite home, moving with such rapidity under the shadow of the leaves and branches that they are rarely seen. Many are very pretty and elaborately coloured. The Diana Monkey (*Cercopithecus Diana*), which has gained its classic name from a crescent-shaped white band of long hair stretching across the forehead, is a familiar example of these Guenons, frequently to be seen in the Zoological Gardens. Another Guenon which has some resemblance to the Diana is called the Mona, a term which means Tailed Apes or Monkeys (the diminutive of Mona is "Monikin," whence the popular term Monkey).

The Sacred Apes, or *Semnopitheci*, may be described as Monkeys with long hind-limbs larger than the fore-limbs, with slender bodies usually highest at the tail, round heads, with not very prominent faces, and very long tails. They have callous pads on the haunch-bones, and in some there are slight folds inside the cheeks, but no pouches. The hands have thumbs. They are all slightly made, though varying considerably in size. The Black-Crested Monkey is very characteristic of the group, and is a native of Sumatra. It has a long and slender body, very long hind-legs, the fore-legs are short, the head small, and the tail very long. The Hoonuman (*Semnopithecus entellus*) is the most venerated of the Sacred Monkeys of the Hindoos, and when fully grown measures four feet and a half in length, and the tail is considerably longer than the body. It associates in great troops, which abound—thanks to the native belief in their semi-divinity—near towns and plantations. They watch and steal with impunity and ability

and are amusing when young, but become savage and disagreeable when old.

Of the **Anthropoid** Apes, those most nearly approaching in general appearance to the *Cynomorpha*, or Dog-shaped Monkeys, are the Gibbons (*Hylobates*), which inhabit India, Siam and Malaysia generally. They are less human-looking than the Orangs, smaller and more slender, but when they walk for a short distance erect, with the arms held above the head balancing the body, their resemblance to a small and hairy "lord of creation" is considerable. A very slight glance distinguishes them from the Orangs; they have straight backs, small heads with large eyes and rather prominent chins, very long forearms, callosities on the hind-quarters, and no visible tail. They are most active, graceful creatures, leading an arboreal life, swinging from bough to bough with the greatest ease. To the anatomist they present many complicated problems; for, although evidently not so high in the animal scale as the Orangs and Chimpanzees, they have some points about them which cause them to resemble Man more than they do these great Apes, and others which cause them to resemble the large army of Monkeys.

The Orang-Utan (*Simia satyrus*) is a native of Borneo and Sumatra, where it lives in the hot steaming forests. It is the largest Asiatic Anthropoid Ape, and appears to lead a very solitary life, never appearing in companies, but only singly, or at most in pairs. Its brown skin and long reddish chestnut hair give it a very characteristic appearance. It is a large and heavily built animal, with long, powerful, hairy arms, and a rather sad expression of face, while the ears are small and delicately shaped. By means of its long muscular arms it can pass from branch to branch and tree to tree with considerable rapidity, but its movements on the ground are cautious and uncertain, probably on account of the peculiar structure of the hind-limbs, which are very loosely jointed to the hip-bones, and are destitute of the strong ligament which in Man binds the thigh-bone to the hip-bone. The young Orangs, like most of the great Apes, are very docile, quiet, and affectionate creatures, but as they grow older become less amiable, and give way to sullen if not violent fits of rage. Those which have been kept alive in captivity for any length of time do not appear to show quite so much intelligence and liveliness of character as

Adult male Chimpanzee

Young female Orang-Utan

the chimpanzee, being more sedate and quiet in their general behaviour. They display considerable affection for those who tend or are kind to them, and one little female that I had the opportunity of constantly visiting became very devoted to me, throwing her arms round my neck, kissing me on both cheeks, and evincing every mark of pleasure at my arrival.

The Chimpanzee (*Troglodytes niger*) is African in range, being found on the coast of Guinea and farther inland. It stands about four feet high, and has very dark, almost black hair, a broad face, small nose, large mouth and upper lip, large brow-ridges, and large ears. The arms are long, and the hand is narrow but as long as the foot. The sole of the foot can rest flat on the ground when the animal stands or walks erect. The backbone shows the beginning of the curves characteristic of Man. The general expression of the face is singularly human, the eyes being wonderfully expressive and twinkling when the Chimpanzee is excited and pleased. The animal is essentially a forest-dweller, though it is said to spend a good deal of its time on the ground rather than among the branches. It appears to be social in its habits, and a colony of Chimpanzees will often make serious raids upon banana and other plantations. Not only is it the most human in appearance of all the great Anthropoid Apes, but it is the most imitative of the habits of Man, and a glance at the photographs facing pages 401 and 408 will show how singularly human and expressive is the face.

The Gorilla (*Gorilla gorilla*) is the largest and most powerful of the Anthropoid Apes, and is found only in a very restricted area between the Niger and the Congo in Western Africa. Owing to its shy, retiring habits, and fierce, savage nature, it has so far been impossible to study this great Ape as closely as has been done with the so closely related chimpanzee. It is stated that the Gorillas go about the dense forests in families, with but one adult male, who sooner or later has to dispute his right to leadership of the band with another male, whom he slays, or is himself vanquished. The Gorilla is an absolute contrast in character to the lively and readily tamed chimpanzee, being gloomy, ferocious, and utterly untamable. Monsieur du Chaillu's statement that the enraged Gorilla beats its breast—a statement that has been challenged with the singular asperity and bitterness peculiar to self-appointed, ignorant critics—has been proved to be absolutely correct, for a young Gorilla

exhibited in the Zoological Gardens in London was observed repeatedly to do so during its fits of passion. In its search for the berries and other fruits and roots upon which it feeds, the Gorilla wanders through the forest, walking partly on the bent hand, as does the chimpanzee, though it is stated that the Gorilla uses the palm and not the back of the hand, as is the habit of the chimpanzee. The huge Ape evinces no desire to run away when he sees the approach of a human enemy, but, according to Dr. Savage, "when the male is first seen, he gives a terrific yell, that resounds far and wide through the forest, something like Kh-ah! Kh-ah! prolonged and shrill."

In making an attack the Gorilla rises to an almost erect attitude, when, if adult, he reaches a height of some five feet, and is a most formidable adversary. With perfectly black skin and coat, a rather bullet-shaped head, small closely applied ears, a large mouth with sharp shining teeth, and a most evil expression of face, the Gorilla presents, indeed, an appalling appearance of savagery; the extraordinarily broad shoulders, deep chest, and enormously muscular arms and hands heightening the impression of tremendous brute force. Small wonder, therefore, that the natives hold this veritable wild man of the woods in peculiar superstitious dread and fear, seeing in his savage nature enshrined the spirits of departed warriors.[1]

The fossil remains of Apes are known from the Miocene strata of France, and have been referred to two genera, *Pliopithecus*, which appears to be closely related to the modern gibbons, and *Dryopithecus*, a more man-like form, which seems to have been as large as a chimpanzee, and probably the Miocene ancestor of that animal. The most famous fossil Anthropoid is the *Pithecanthropus erectus*, the partial remains of which were discovered by Monsieur Dubois in the island of Java, in andesite tufa of Pliocene, or at least Pleistocene age. Much wordy warfare has taken place over these regrettably incomplete remains of an animal which was undoubtedly of a high-grade anthropoid character.

[1] The above brief outline of the Apes and Monkeys has been compiled from the writings of Dr. P. Martin Duncan, F.R.S., Dr. J. Murie, and Prof. F. E. Beddard.

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Made and Printed in Great Britain by
The Greycaine Book Manufacturing Company Limited, Watford
15.429